

# COMPUTER CROP MODELS AS A MANAGEMENT TOOL

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# Scope

- Crop modelling History
  - CANEGRO sugarcane model
  - Evolution of a benchmarking tool
  - Models as a management tool
    - Harvest Planning
    - Performance monitoring
    - Replant Planning
    - Irrigation scheduling
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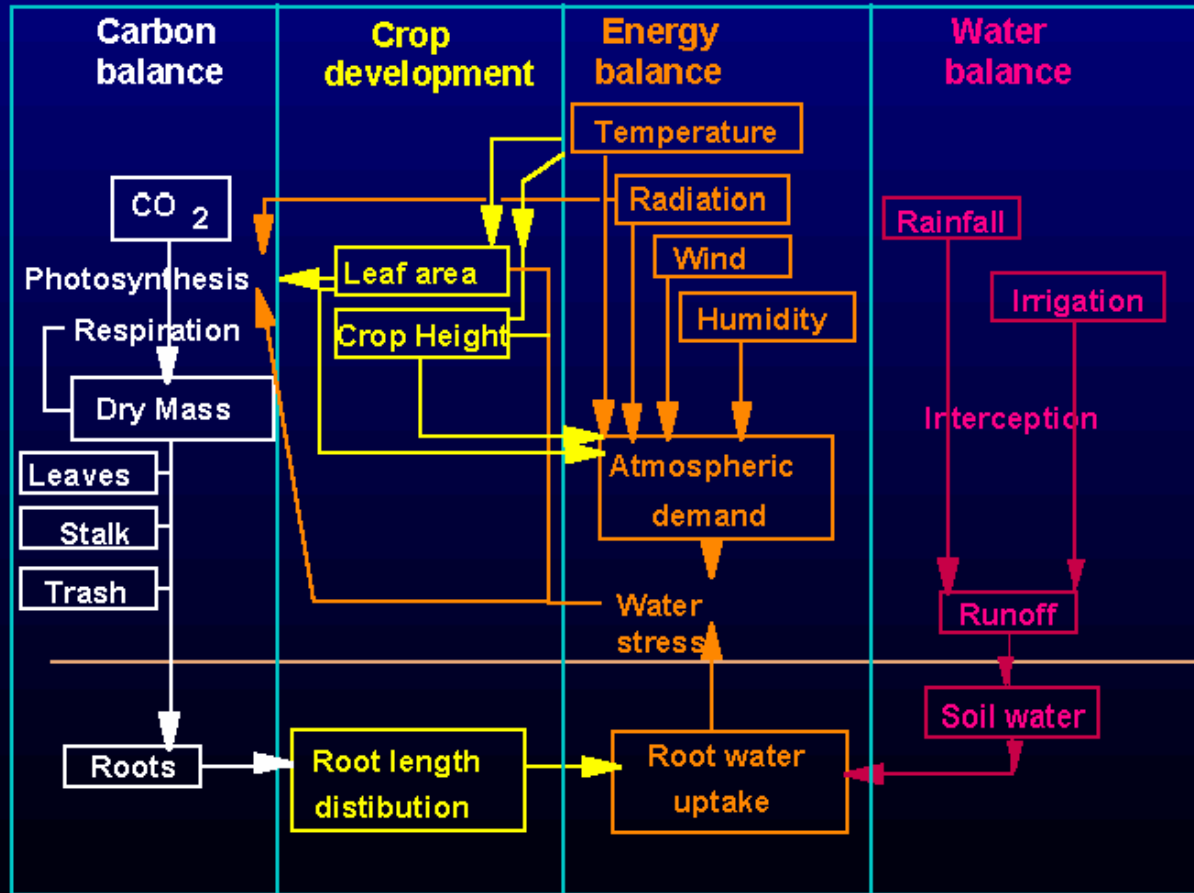
# History

- Development started during the 70's
  - Initially of Maize, Wheat, Sorghum
  - Development on Sugarcane models began during early 80's
    - South Africa – CANEGRO
    - Australia – AusCane, Qcane, APSIM
    - Many others throughout the world
  - Initially a research tool to compliment conventional experimentation
  - Pressure to use models to assist agri-business
  - Development continues today
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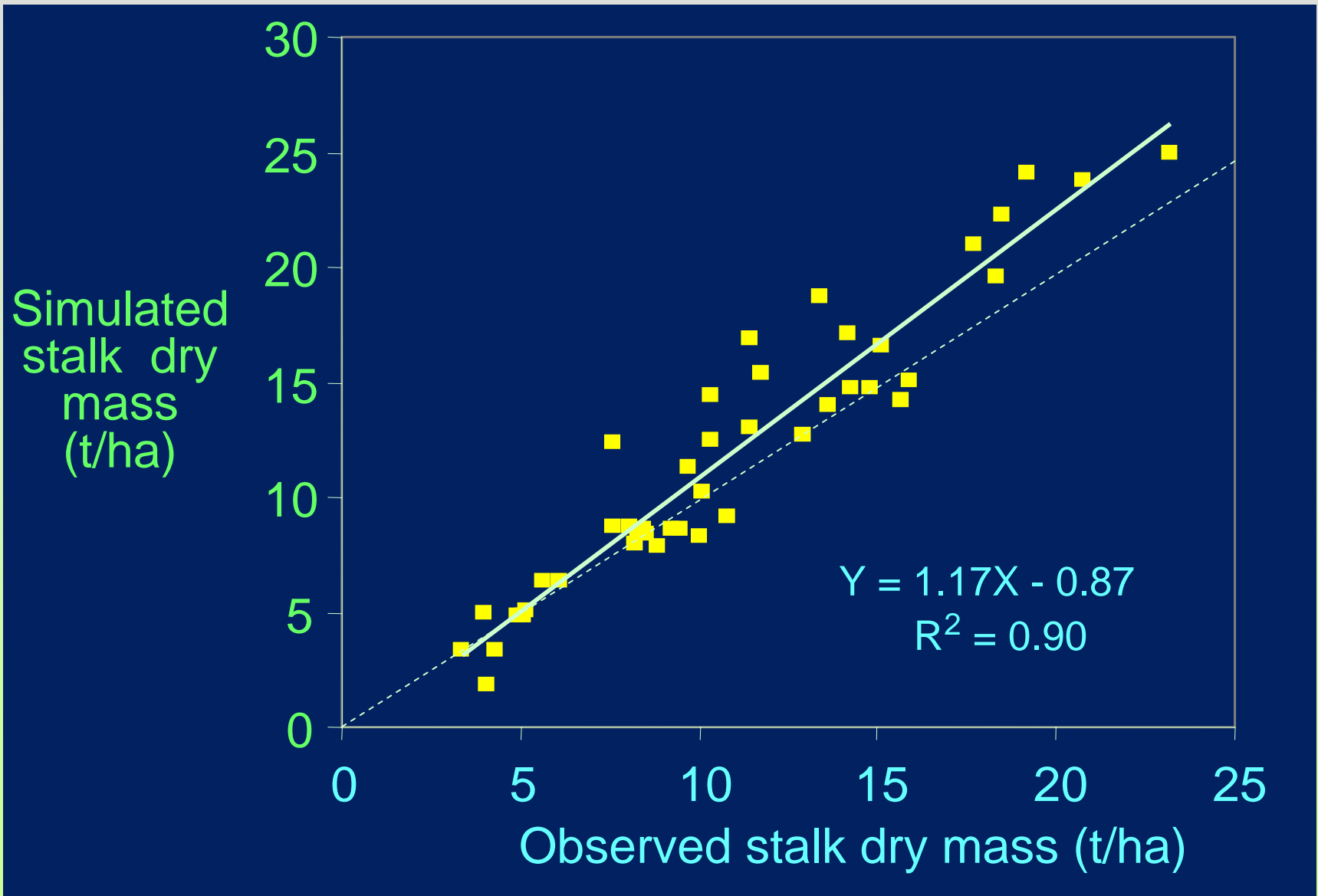
# The CANEGRO crop model

- Developed primarily in South Africa
  - International consortium – DSSAT
  - Primarily climate-driven
  - Features
    - Hesketh-McCree RUE-based Carbon Balance
    - Water balance – multi-layer single dimension model
    - Energy Balance – Sugarcane-specific Penman-Monteith
    - Mechanistic canopy development routine
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# CANEGRO - Conceptual Basis

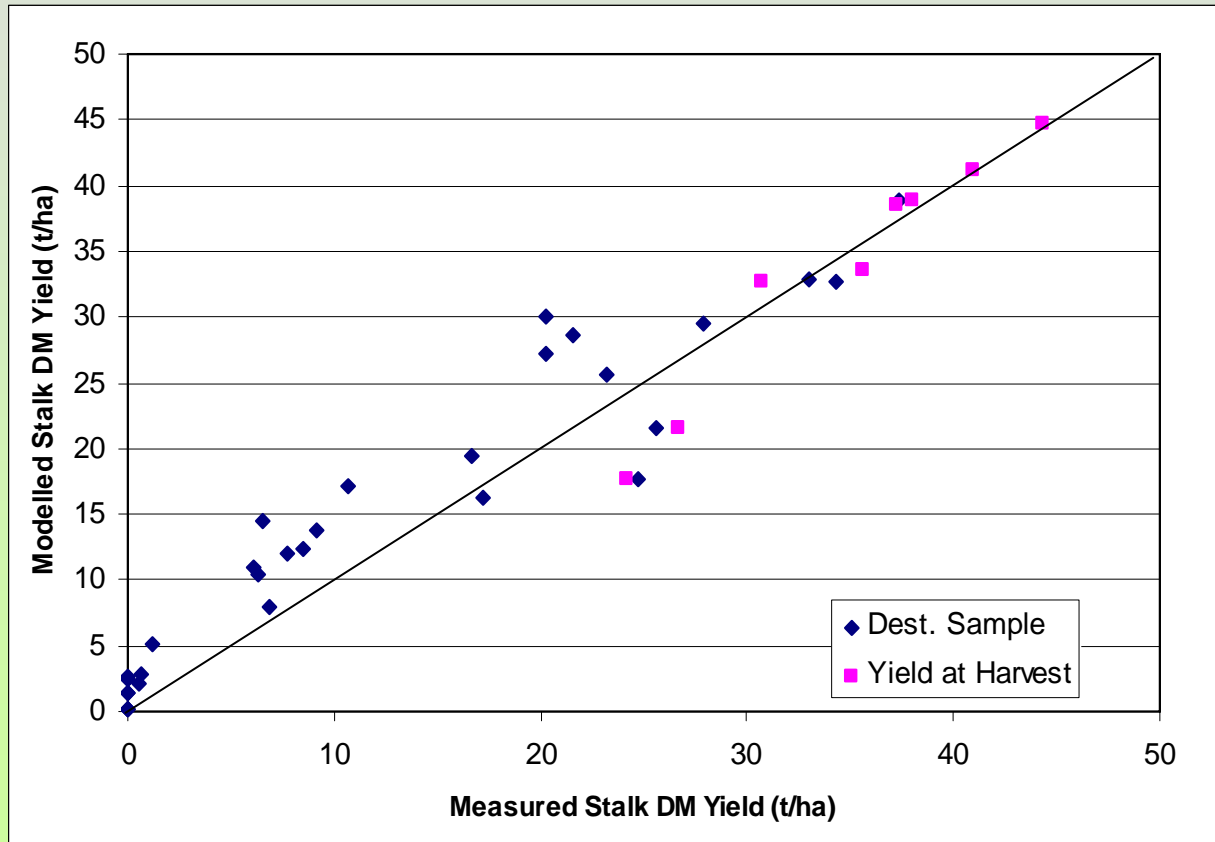


# Model Validation – South Africa

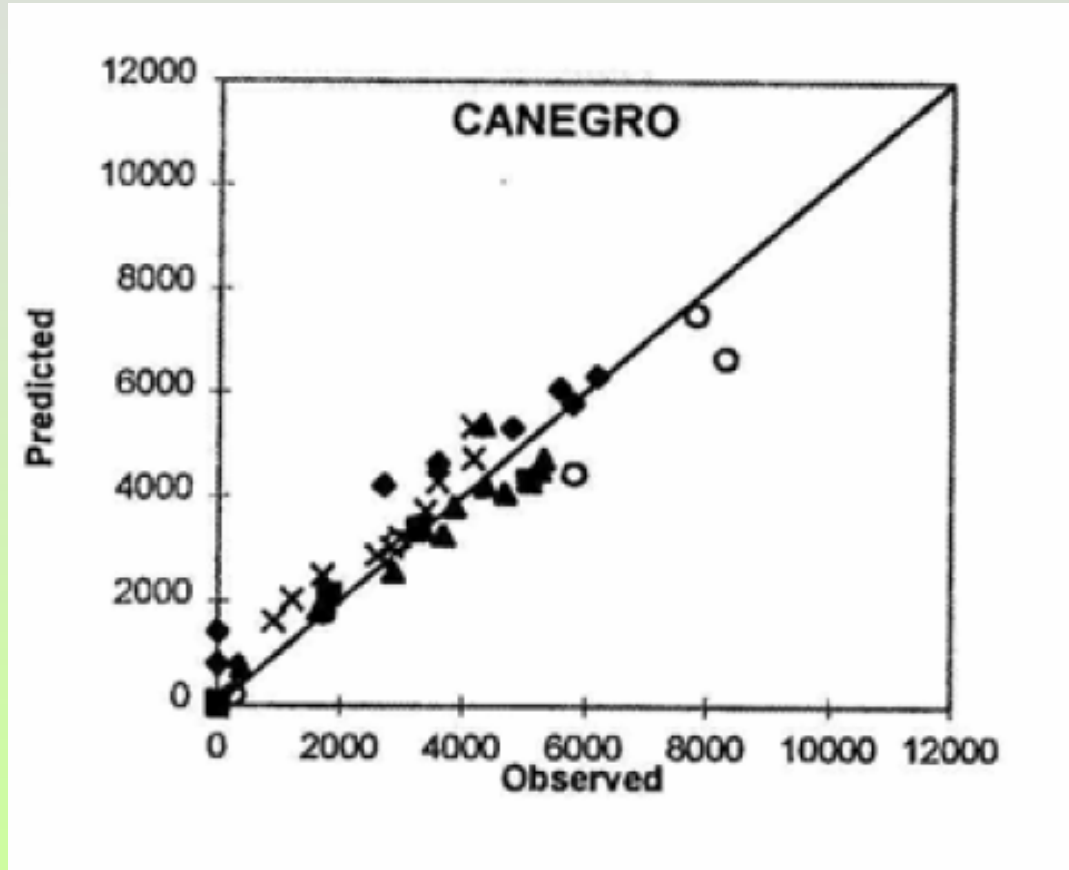


# Model Validation - Swaziland

- Stress Trial – 4 levels of stress, 4 seasons
- Destructive sampling – 2 monthly intervals and
- Yield at Harvest



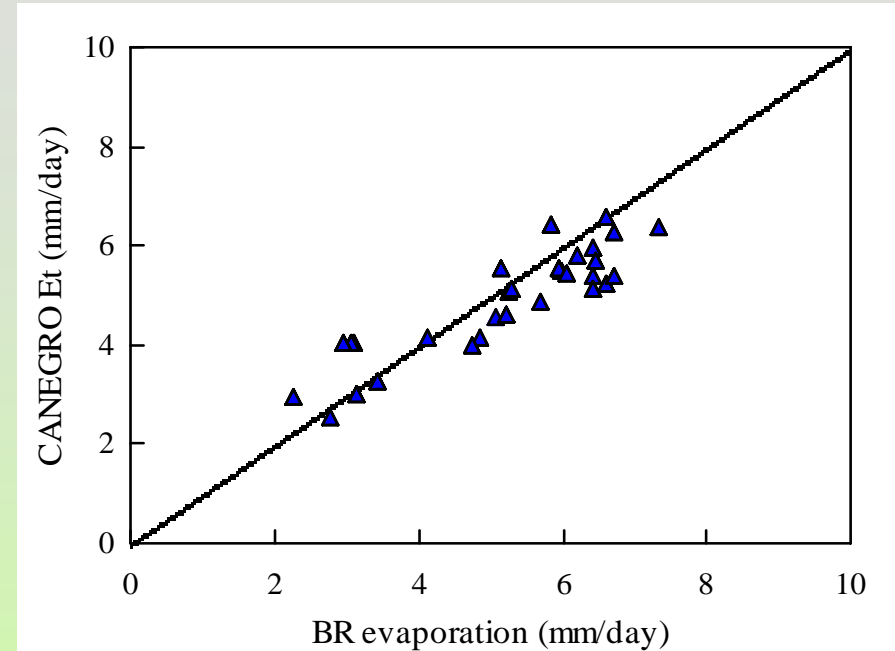
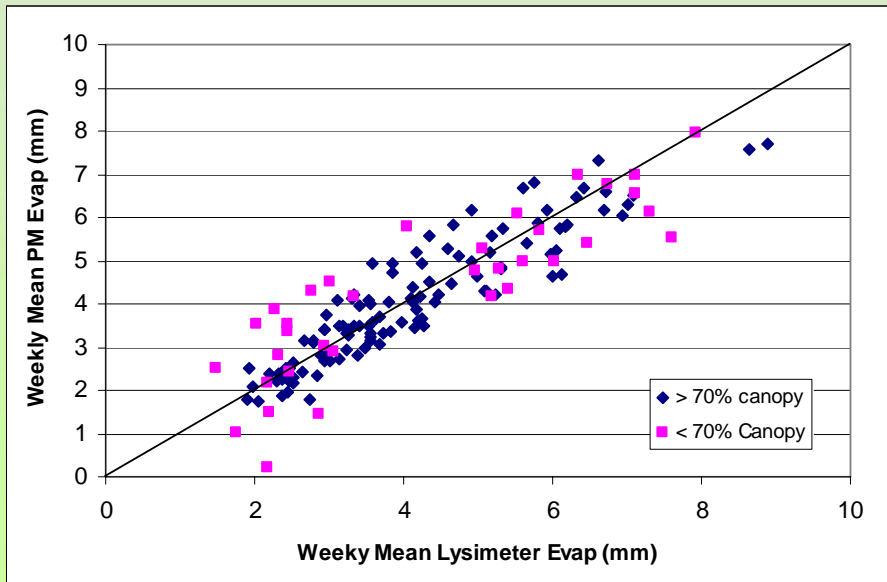
# CANEGRO Validation - International



- 4 sites in Australia
- 1 site in Hawaii

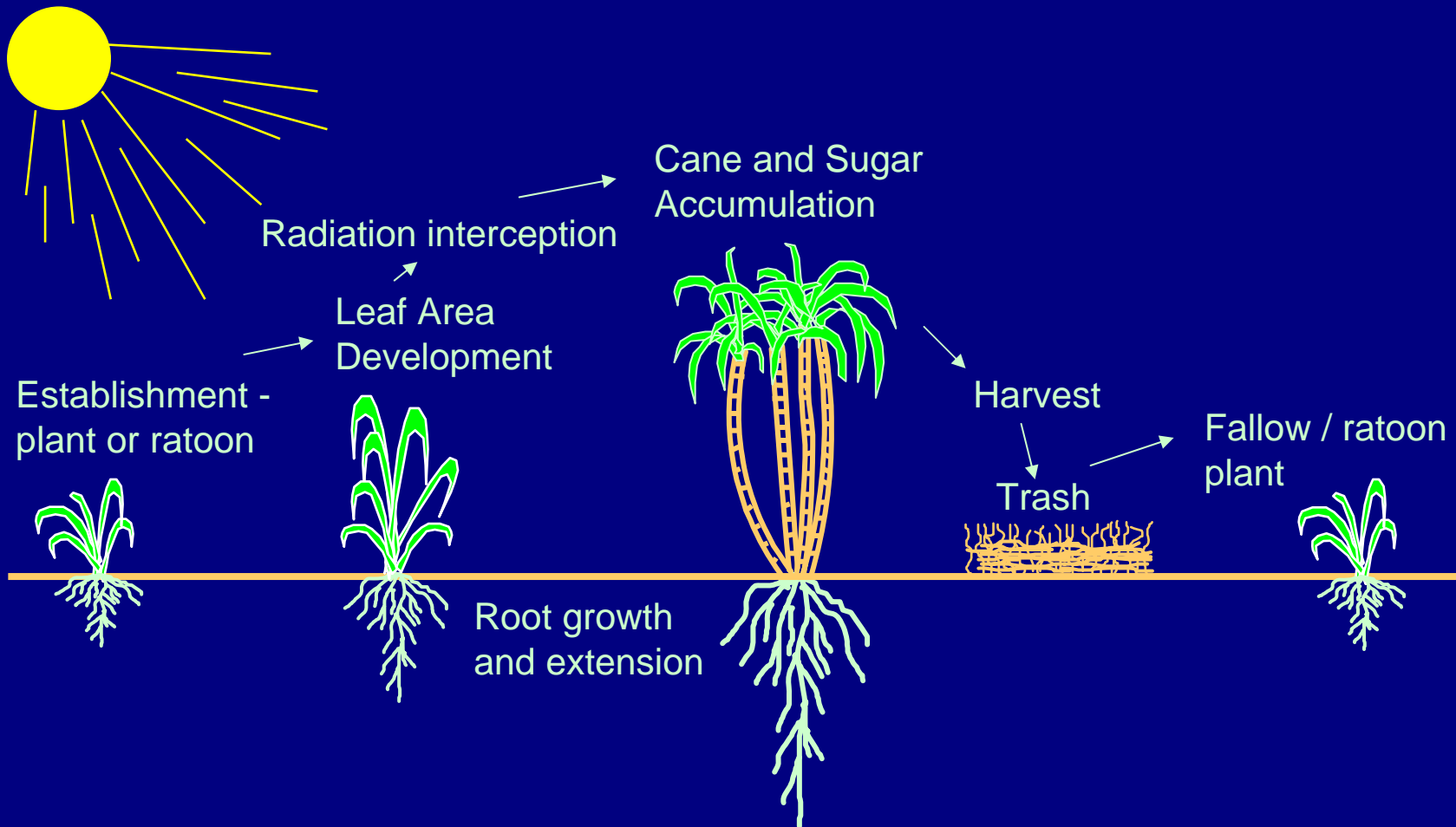
# CANEGRO Validation – Evapotranspiration Estimate

- Penman-Monteith sugarcane reference Et approach
- Original Validation – Three years Lysimeter data – Pongola, South Africa

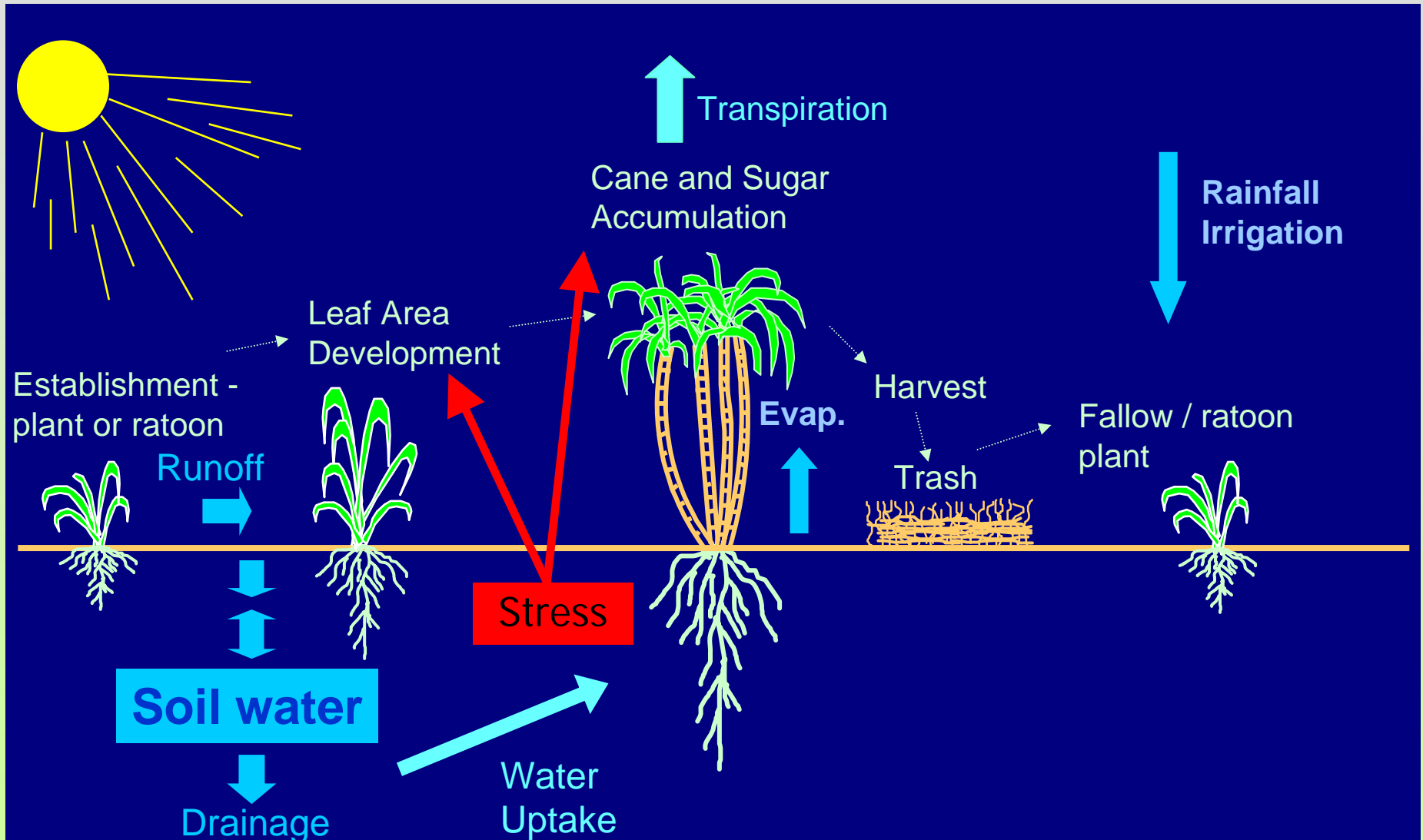


- Et Validation
- Bowen ratio Measurements, Swaziland

# Potential Yield Calculation



# Water Limited Yield Calculation

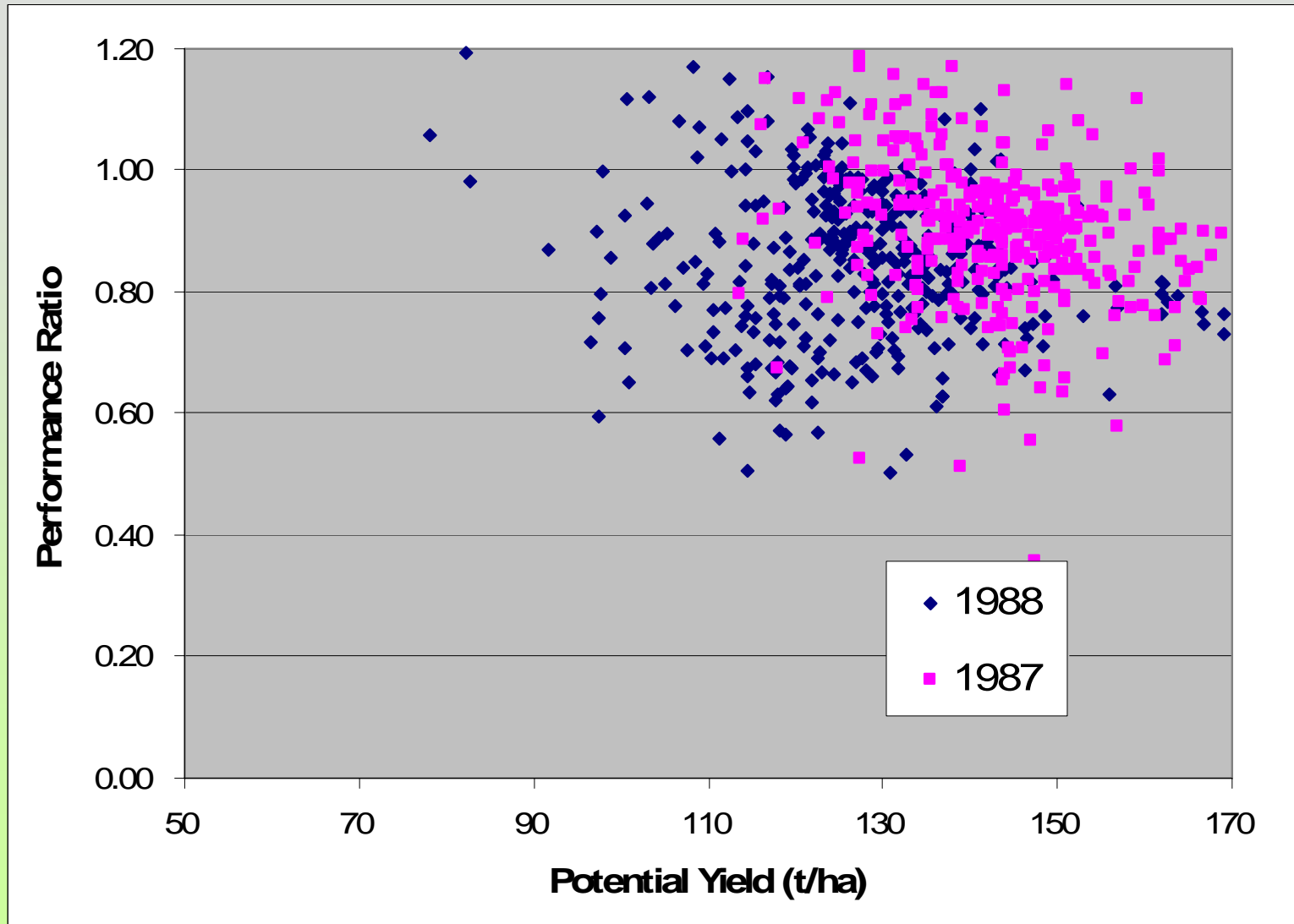


# Evolution of a Benchmarking Tool

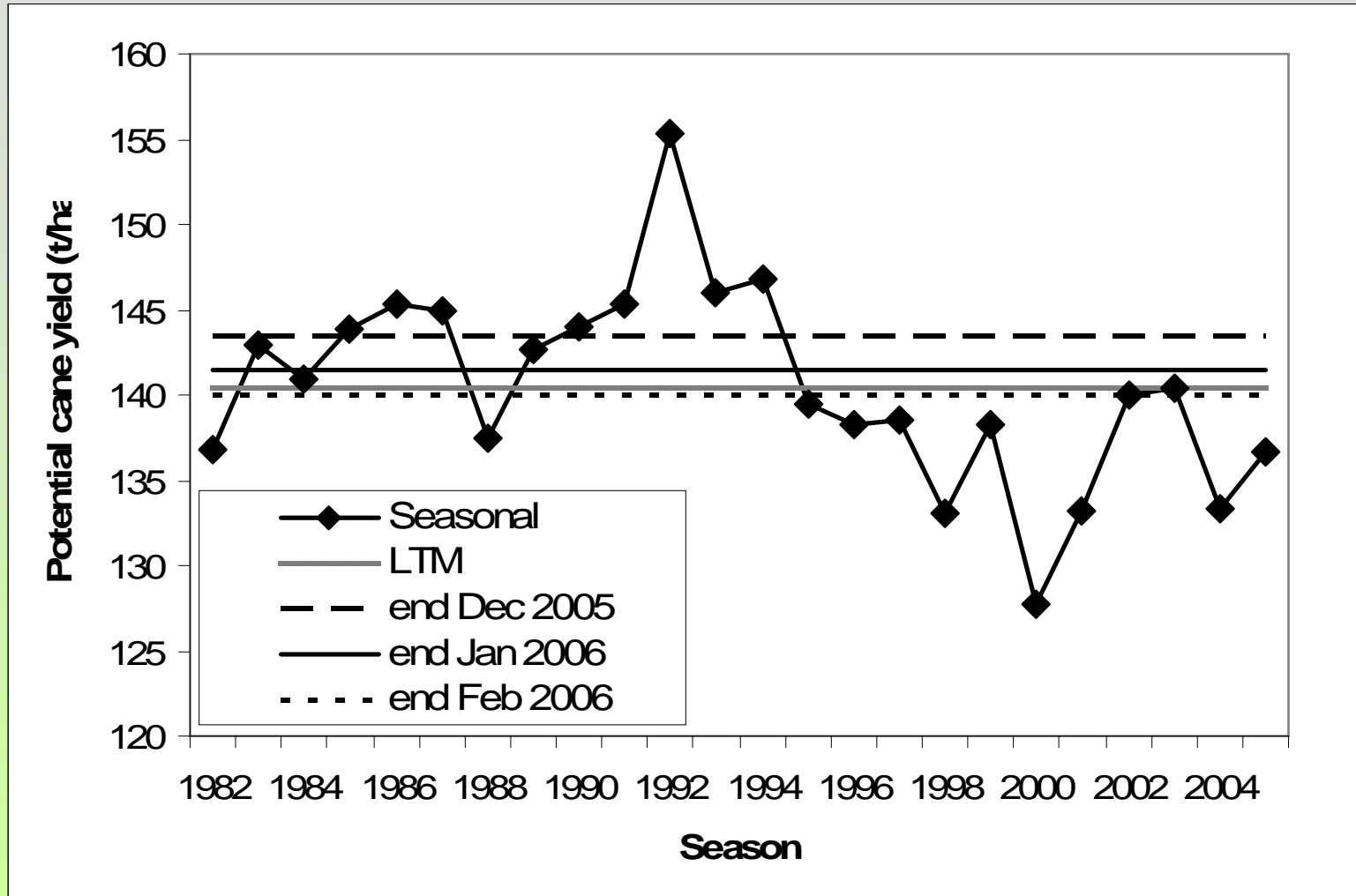
## Step 1 – Potential Yield

- Questions raised regarding performance at RSSC, Swaziland during the late 80's
  - 1987/88 season avg yield = 130 t/ha
  - 1988/89 season avg yield = 107 t/ha
  
  - Why the big drop?
-

# Season Potential and Performance



# Potential Yield - Season Benchmarking



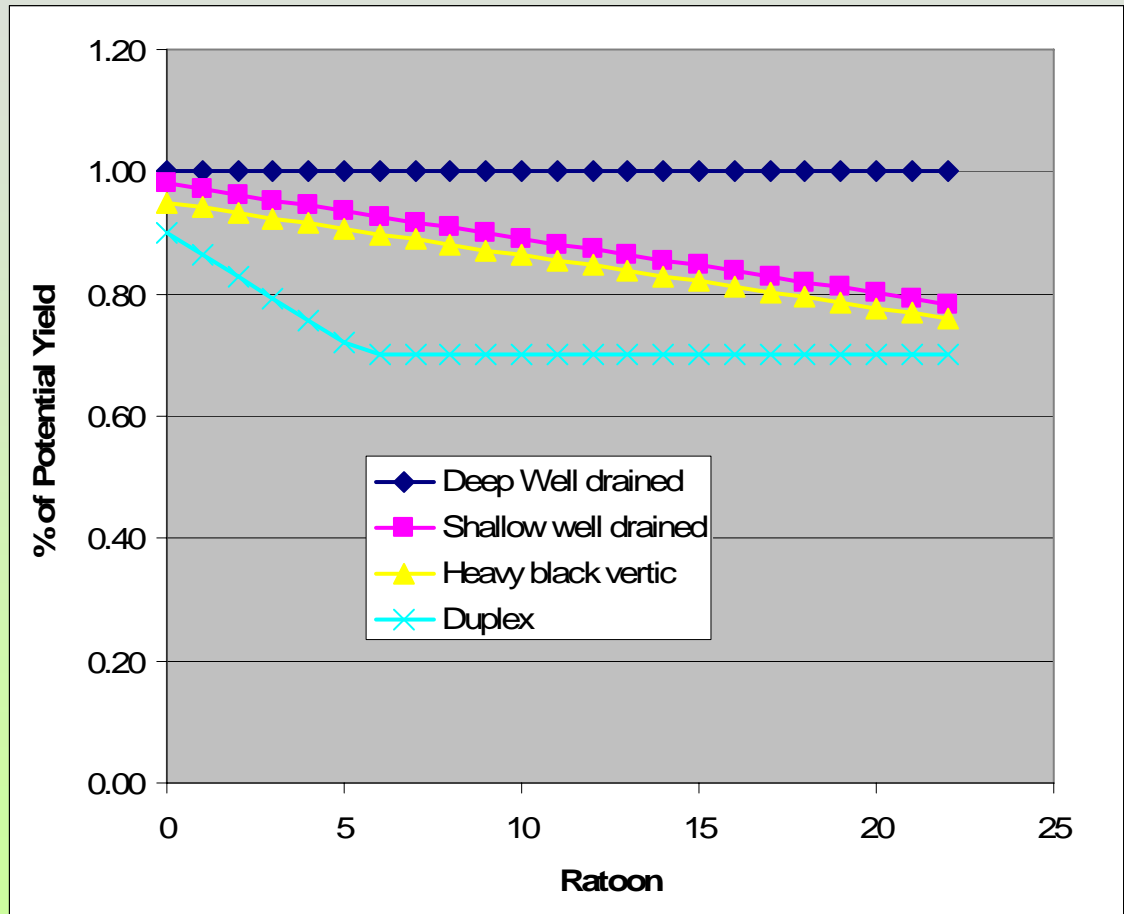
# Evolution of a Benchmarking Tool

## Step 2 – Attainable Yield

- Questions regarding field performance comparisons raised
  - Potential yield concept able to cope with seasonal variability
  - Need to consider other agronomic constraints
  - Led to development of Attainable Yield concept
-

# Attainable Yield Concept

- Identified the soil/ratoon interaction as the most important agronomic consideration



# Attainable Yield Concept

- Soil/Ratoon matrix combined with other agronomic factors in a simple multiplicative model of the form:
  - $\text{AttYld} = \text{PotYld} * \text{Soil/Rat fac} * \text{Variety fac} * \text{Irrig fac}$
  - Eg. Shallow well drained soil, 6<sup>th</sup> ratoon, NCo376, Drag-line irrigation system
  - $\text{AttYld} = 140 \text{ t/ha/an} * 0.94 * 1.00 * 1.00 = 132 \text{ t/ha/an}$
-

# Examples of model use in commercial operations – CanePro Cane Management Software

1. Harvest Planning and Yield Estimates
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# The Problem

- Large Estates
    - 3500 ha – 21000 ha
    - 100 – 1000 fields
    - Supplying 1 – 2 mills
  - Complex harvest planning decisions
  - Need for accurate estimates
    - Usually majority or only mill supply
    - Implications for season start and duration
  - Need for in-season revision of estimate
-

# Estate Practice – Prior to CanePro

- Estimate largely based on 5-year mean productivity
  - Realise the effect of age and climate on yield but unsure how to incorporate into early estimates
  - Rely on Section Managers subjective yield assessment
  - Yield revisions 2 - 4 times per season
-

# The Need

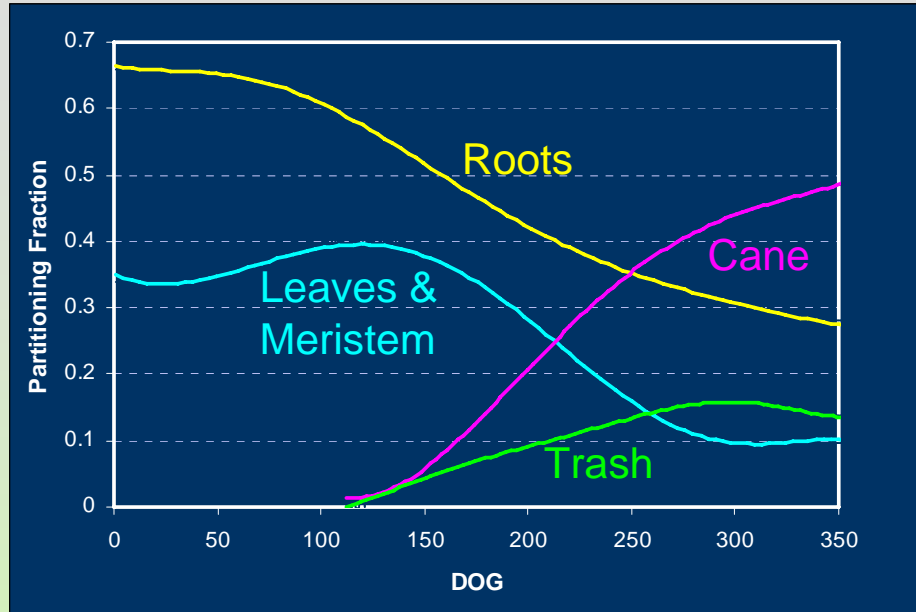
- Easy-to-use harvest planning tool which:
  - Is flexible
  - Integrates the effect of climate and age on yield
  - Provides real-time in-season revisions
  - Model inputs simple and easy to obtain

# How?

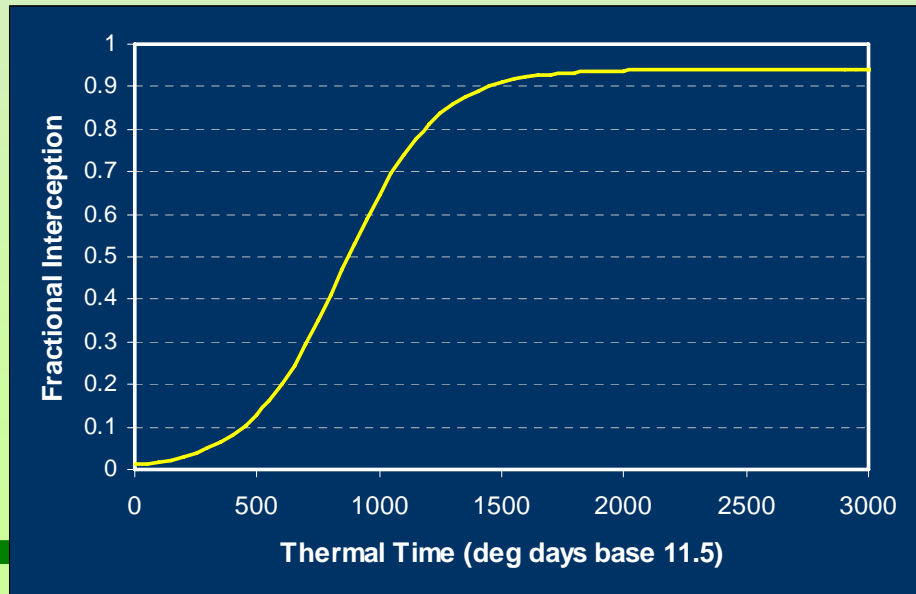
- Combine commercially available harvest planning engine with a simplified yield simulation model and performance ratio concept
-

# Simplified Yield model

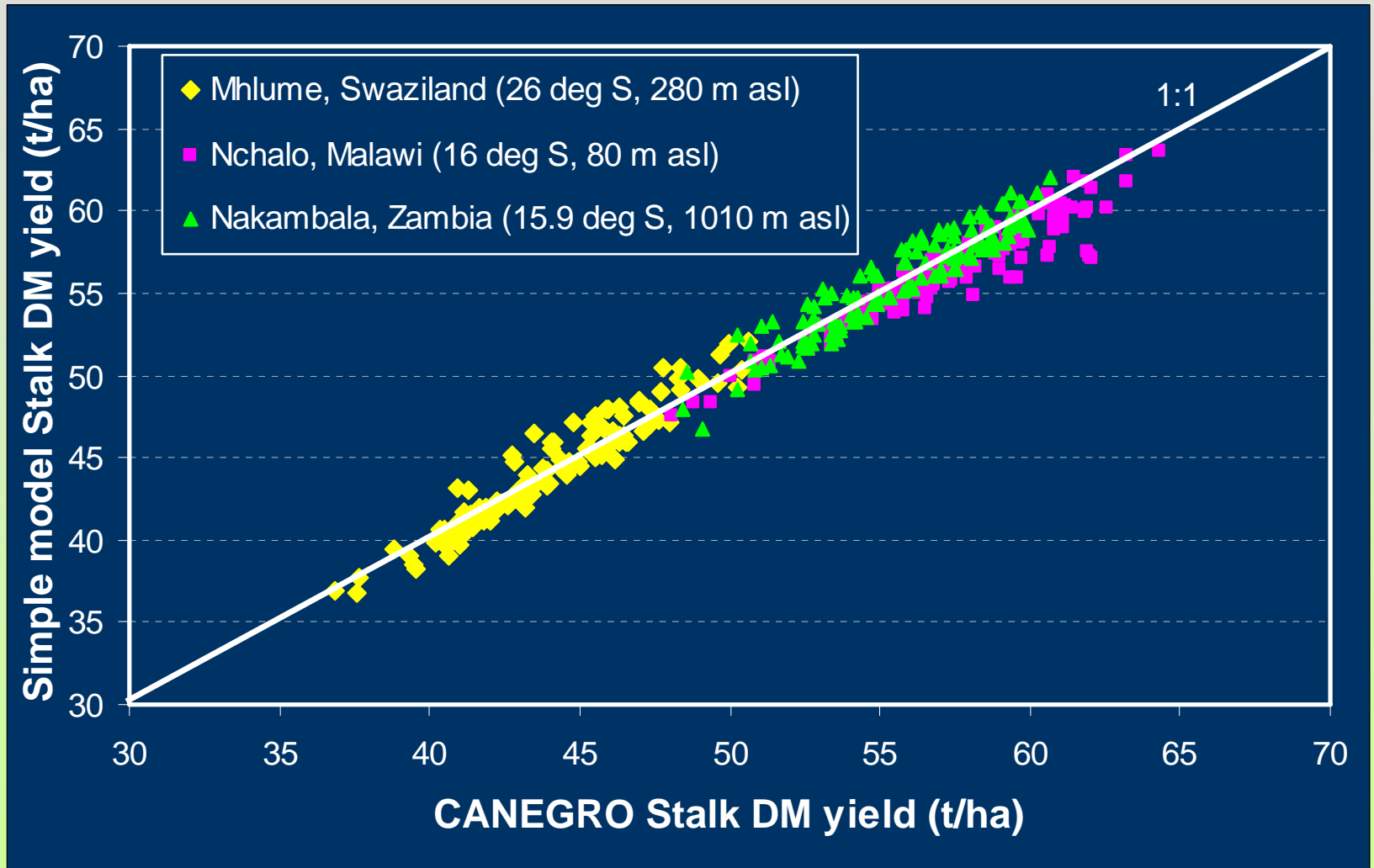
- Potential yield model developed using CANEGRO RUE model (McCree & Hesketh) and DM partitioning algorithms



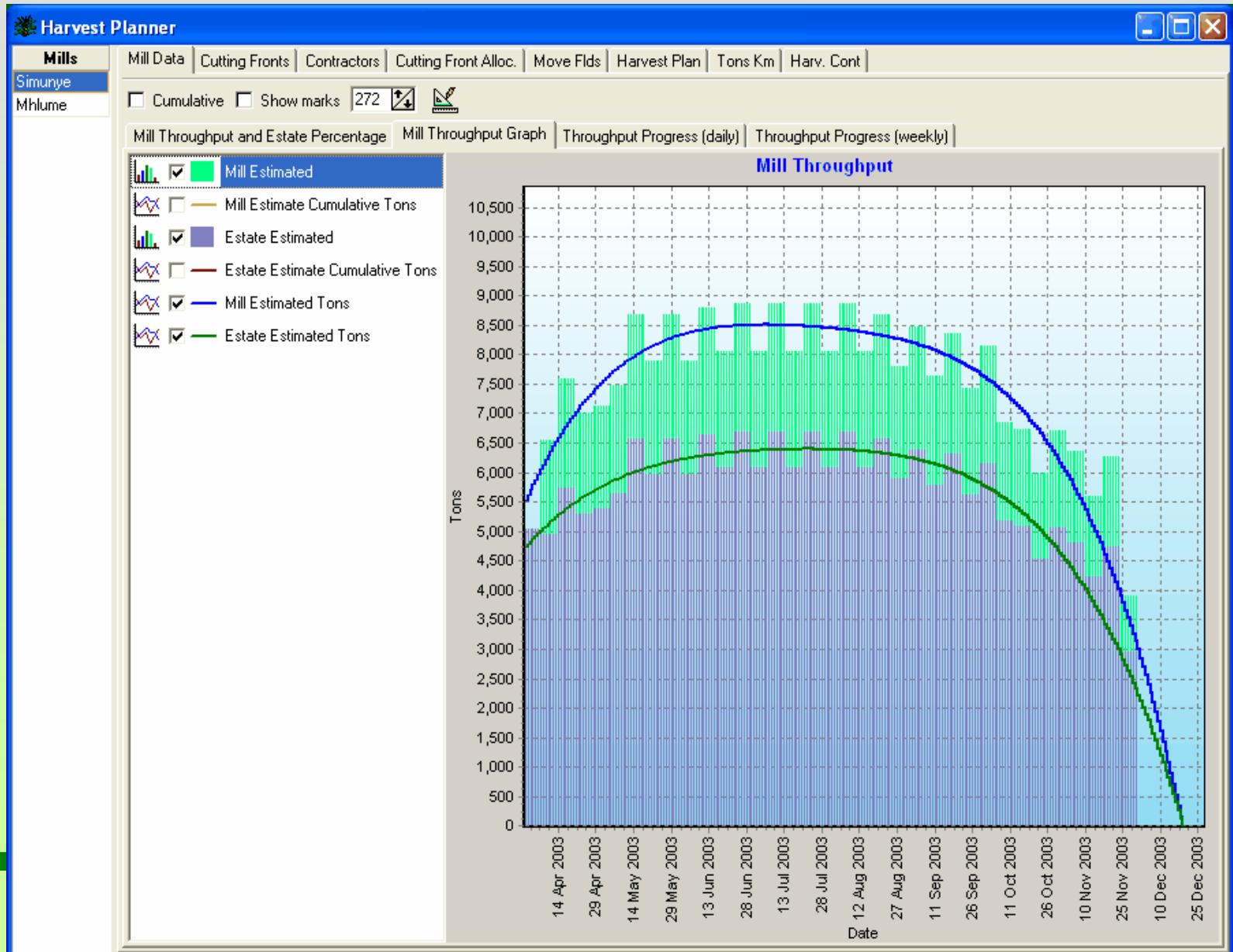
- Empirical temperature based radiation interception curve (base 11.5)



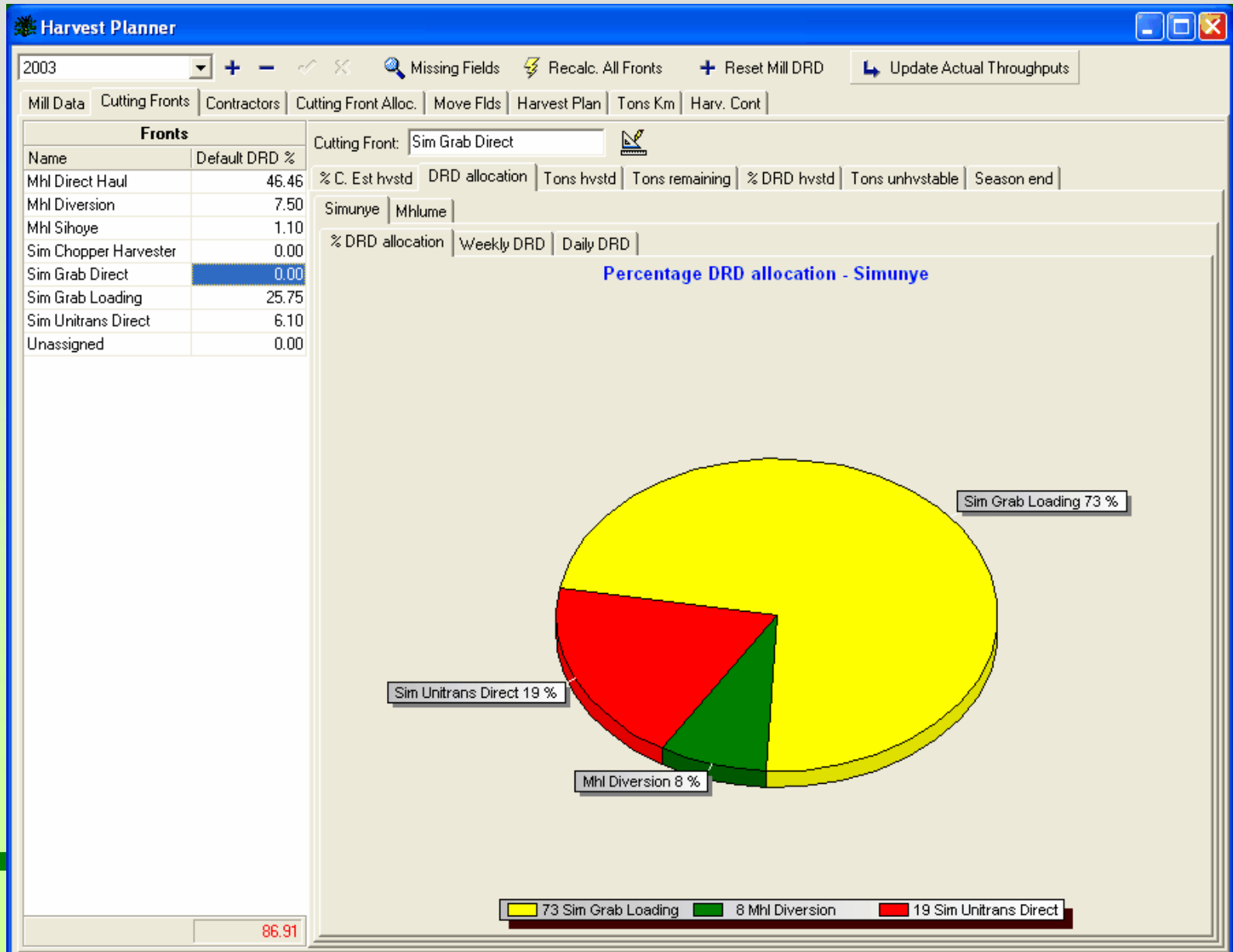
# Model Validation



# Step 1- Crush Programme



# Step 2 – Cutting Fronts



# Step 3 – Field Harvest Order

**Harvest Planner**

2003

Missing Fields Recalc. All Fronts View Editor + Reset Mill DRD Update Actual Throughputs

Mill Data Cutting Fronts Contractors Cutting Front Alloc. Move Flds Harvest Plan Tons Km Harv. Cont

From cutting front: Mhl Direct Haul Set seq to grid sort order

Cutting Sequence Data				Area (ha)		Estim...
Name	Seq. ... ^	Grow start	Cut date	Carried over	Actual	To Harvest
215010	1	28/02/2002	10/04/2003	0.00	13.50	13.50
215020	2	01/03/2002	10/04/2003	0.00	10.80	10.80
215030	3	27/02/2002	10/04/2003	0.00	8.10	8.10
402011	4	12/05/2002	10/04/2003	0.00	2.00	2.00
402012	5	12/05/2002	11/04/2003	0.00	1.80	1.80
403010	6	08/03/2002	11/04/2003	0.00	15.20	15.20
403020	7	09/03/2002	11/04/2003	0.00	13.10	13.10
403030	8	27/02/2002	11/04/2003	0.00	10.60	10.60
416010	9	02/03/2002	12/04/2003	0.00	10.80	10.80
416020	10	05/03/2002	12/04/2003	0.00	6.20	6.20
416030	11	28/02/2002	12/04/2003	0.00	7.00	7.00
416040	12	04/03/2002	13/04/2003	0.00	10.90	10.90
520010	13	28/04/2002	13/04/2003	0.00	18.60	18.60
520020	14	25/04/2002	14/04/2003	0.00	19.00	19.00
521010	15	01/05/2002	14/04/2003	0.00	19.40	19.40
521020	16	01/05/2002	15/04/2003	0.00	19.70	19.70
222010	17	04/03/2002	16/04/2003	0.00	4.60	4.60
222020	18	06/03/2002	16/04/2003	0.00	6.80	6.80
222030	19	05/03/2002	16/04/2003	0.00	10.50	10.50
222040	20	07/03/2002	17/04/2003	0.00	11.30	11.30
222050	21	09/03/2002	17/04/2003	0.00	10.90	10.90
223010	22	20/03/2002	17/04/2003	0.00	10.60	10.60
223020	23	15/03/2002	18/04/2003	0.00	13.20	13.20
223030	24	18/03/2002	18/04/2003	0.00	10.00	10.00
223040	25	19/03/2002	18/04/2003	0.00	7.00	7.00

To cutting front:

**General Details**

Name	Cut date	Carried over	S...
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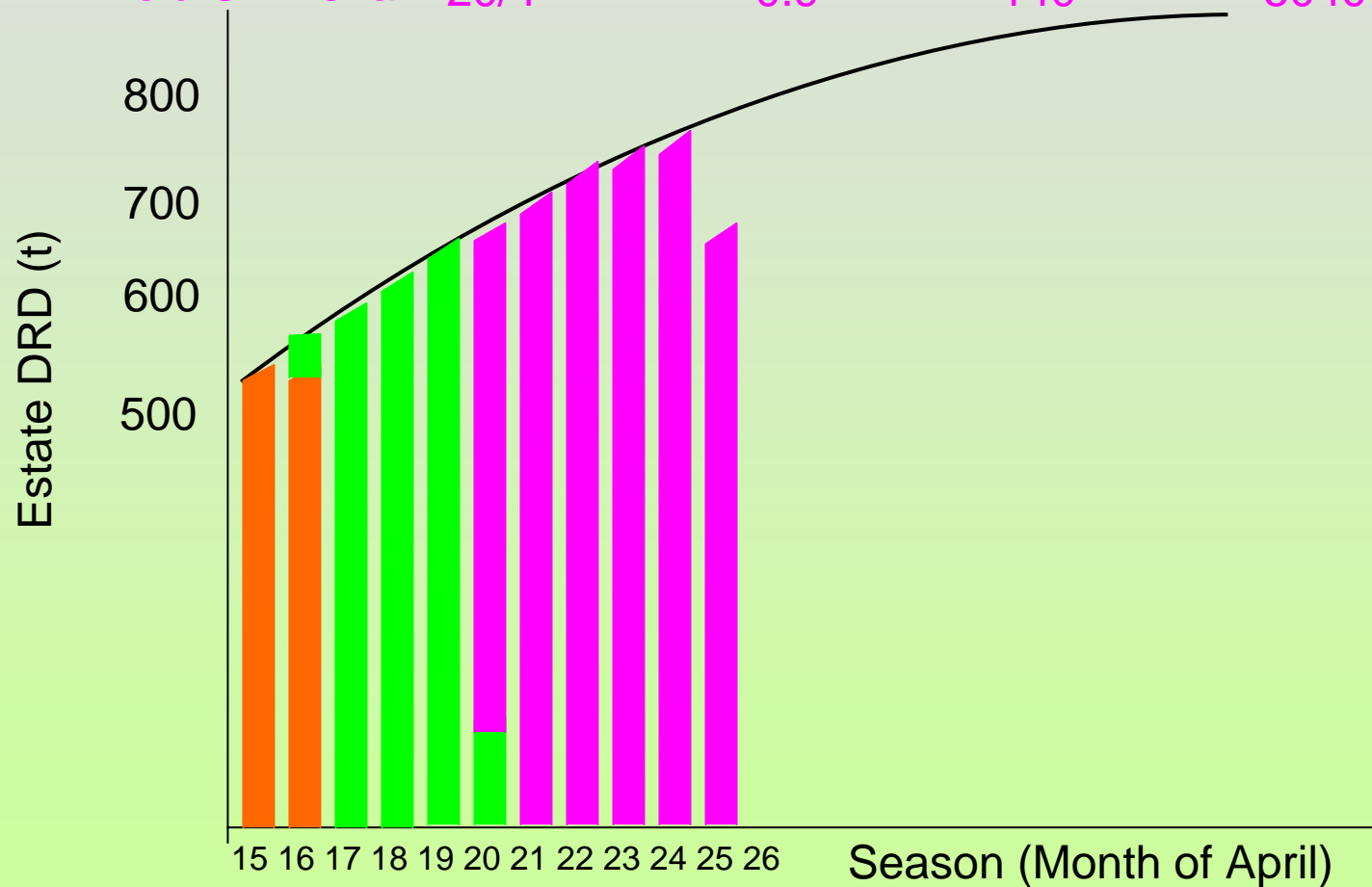
Multiple items can be selected on the left hand side. The selected items have a blue background. Ctrl + Click adds an item to the selection. Shift + Click adds a range to the selection.

Only one item can be selected as the target on the right hand side. The target item has a darker background. Press on the arrow in the central

Field status colours: Time frame:

# Step 4 – Harvest Plan

Order	Field	Size	Cut Start	Perf ratio	Potential yld	Yield (tons)	Cut End
1.	Field A – 10ha	10ha	15/4	0.7	140	980	16/4
2.	Field B – 20ha	20ha	16/4	0.8	140	2240	20/4
3.	Field C – 40ha	40ha	20/4	0.9	140	5040	25/4



# Step 4 (contd...) – Harvest Plan

**Harvest Planner** 2003

Missing Fields Recalc. Front Recalc. All Fronts Show Selected Front Reset Mill DRD

Update Actual Throughputs

Mill Data Cutting Fronts Contractors Cutting Front Alloc. Move Flds **Harvest Plan** Tons Km Harv. Cont

Cutting front

- MHI Direct Haul
- MHI Diversion
- MHI Sihoye
- Sim Chopper Harveste
- Sim Grab Direct
- Sim Grab Loading
- Sim Unitrans Direct
- Unassigned

Drag a column header here to group by that column

Field	Cut date	End cut date	Estimated Cane Yield					
			Tons cane/ha	Total Tons	Tons hvstd	Tons to hvst	Tons unharvestable	Est to
906020	26/07/2003	30/07/2003	107.8	2059.43		2059.43	0.00	
125010	26/07/2003	26/07/2003	97.1	1787.41		1787.41	0.00	
125020	26/07/2003	27/07/2003	83.5	1879.78		1879.78	0.00	
1404	27/07/2003	27/07/2003	142.1	3893.54		3893.54	0.00	
1411	27/07/2003	28/07/2003	135.7	2511.11		2511.11	0.00	
204	27/07/2003	30/07/2003	96.0	3176.95		3176.95	0.00	
131010	27/07/2003	27/07/2003	70.0	553.17		553.17	0.00	
131030	27/07/2003	27/07/2003	82.7	678.02		678.02	0.00	
131040	27/07/2003	28/07/2003	54.3	548.10		548.10	0.00	
131020	27/07/2003	27/07/2003	67.9	800.83		800.83	0.00	
1412	28/07/2003	29/07/2003	134.3	3343.41		3343.41	0.00	
5033	28/07/2003	29/07/2003	136.3	4389.88		4389.88	0.00	
1413	29/07/2003	30/07/2003	140.3	3324.12		3324.12	0.00	
1418	29/07/2003	29/07/2003	139.3	1630.09		1630.09	0.00	
1419	29/07/2003	29/07/2003	142.4	840.42		840.42	0.00	
5032	29/07/2003	30/07/2003	136.6	2746.59		2746.59	0.00	
1414	30/07/2003	31/07/2003	140.4	2106.13		2106.13	0.00	
5012	30/07/2003	31/07/2003	113.1	2623.77		2623.77	0.00	
5031	30/07/2003	30/07/2003	136.9	1341.83		1341.83	0.00	
4012	30/07/2003	02/08/2003	178.0	2865.34		2865.34	0.00	
847010	30/07/2003	04/08/2003	103.0	2440.06		2440.06	0.00	
1415	31/07/2003	31/07/2003	139.8	2824.74		2824.74	0.00	
1416	31/07/2003	01/08/2003	139.2	1531.63		1531.63	0.00	
143010	31/07/2003	31/07/2003	89.2	544.04		544.04	0.00	
143020	31/07/2003	31/07/2003	89.1	882.03		882.03	0.00	
143030	31/07/2003	01/08/2003	86.9	860.72		860.72	0.00	
1,304				2,104,203.4	0.00	2,104,203.45	0.00	

# Estimate Detail

## Yield Data for Field: 315

### - Current season Details

Grow Start Date	25/05/2002
Cut Date	23/04/2003
Estimator Method	Current Estima
Area to Harvest	19.50
Orig. Area to Harvest	19.50
Tons/ha/mnth Est.	8.20
Current Estimate	91.87
Original Estimate	90.53
Official Estimate	0.00
Current Tons	1,791.47
Original Tons	1,765.43
TCHA	100.75
Ratoon	12
Cut Age	10.9
Perf. Ratio	

### - Previous Seasons Yields (TCHA)

2002	93.08
2001	93.62
2000	103.55

### - Previous Seasons Ratoons

2002	11
2001	10
2000	9

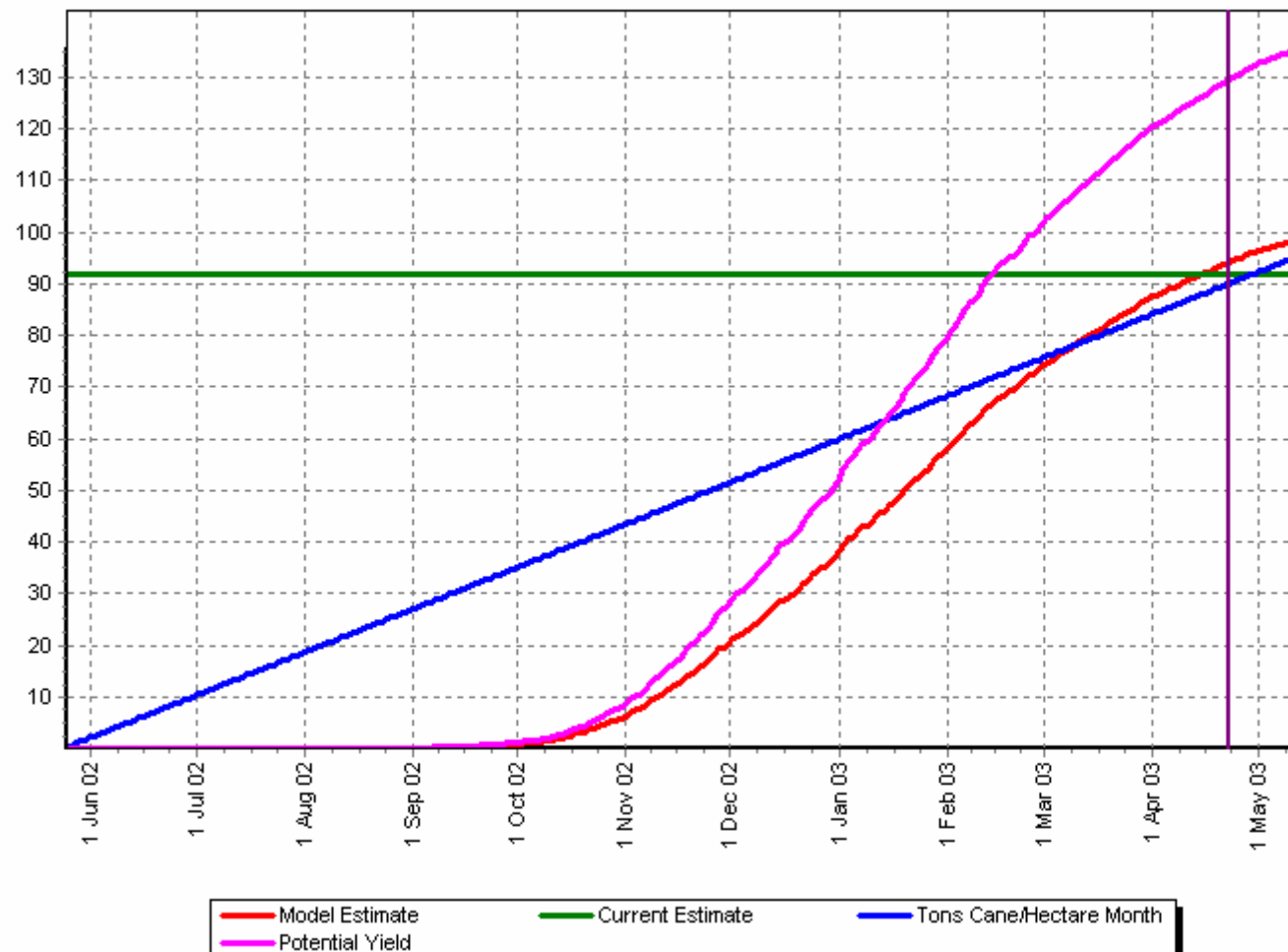
### - Previous Seasons Cut Dates

2002	24/05/2002
2001	30/05/2001
2000	10/06/2000

### - Previous 3 Seasons Perf. Ratios

2002	.68
2001	.69
2000	.81

Graph of Various Estimator Yields (TCH) for 20 Days Past the Cut Date



# Advantages

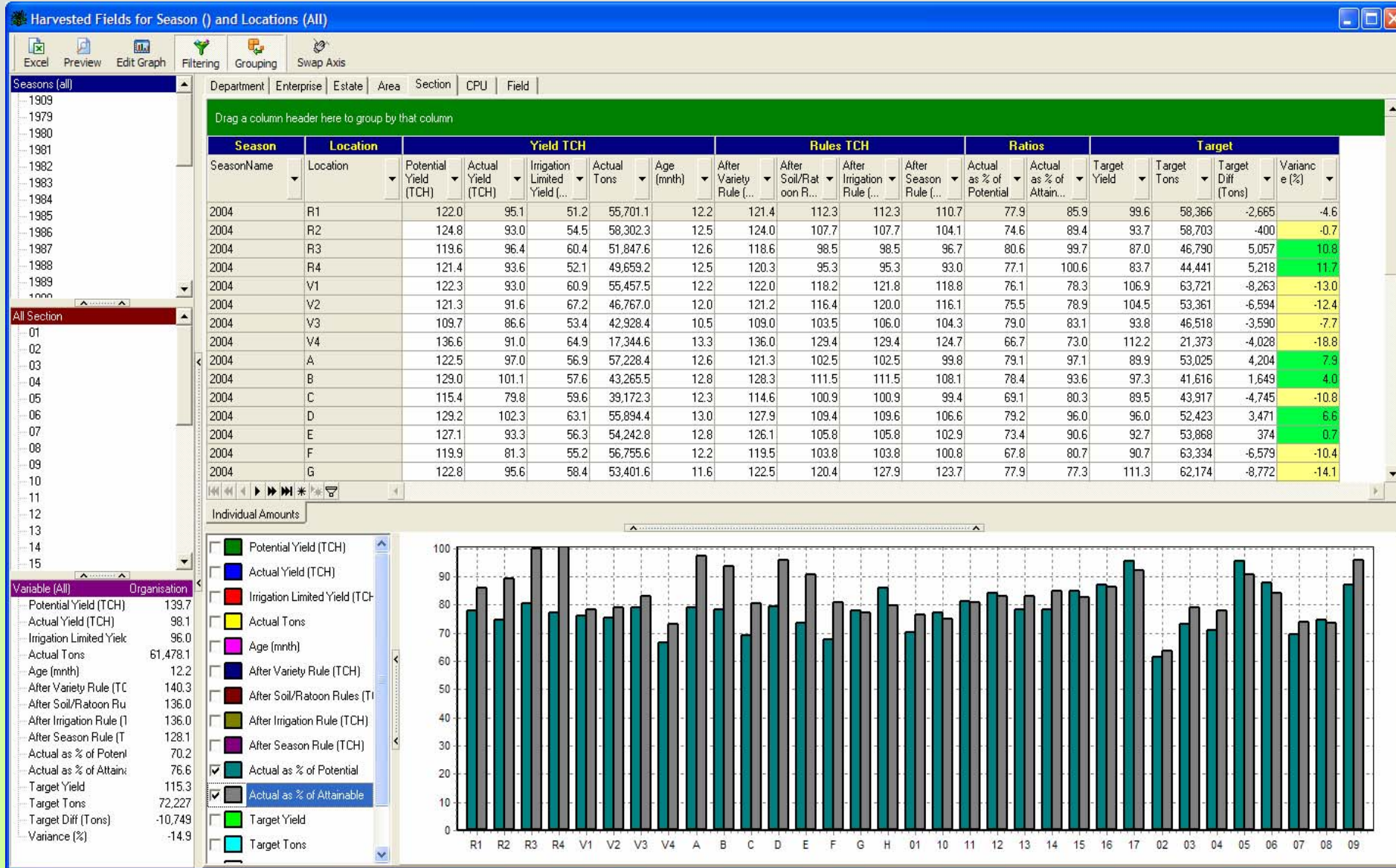
- Flexibility
    - Harvest date and estimate re-calculated if field harvest sequence changed
  - Captures climate and age effects
  - Live in-season
    - Harvest plan continually updated and estimate refreshed
  - Better control of other operations linked to harvest date e.g. ripening
  - What-if analysis w.r.t. season start and duration
-

# Examples of model use in commercial operations – CanePro Cane Management Software

## 2. Performance Monitoring

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# Performance Monitoring



# Advantages

- Allows for comparisons between/within season
  - Allows benchmarking between estates
  - Allows benchmarking between different environments/countries
  - Used to assess manager performance
  - Crucial part of replant planning decisions
-

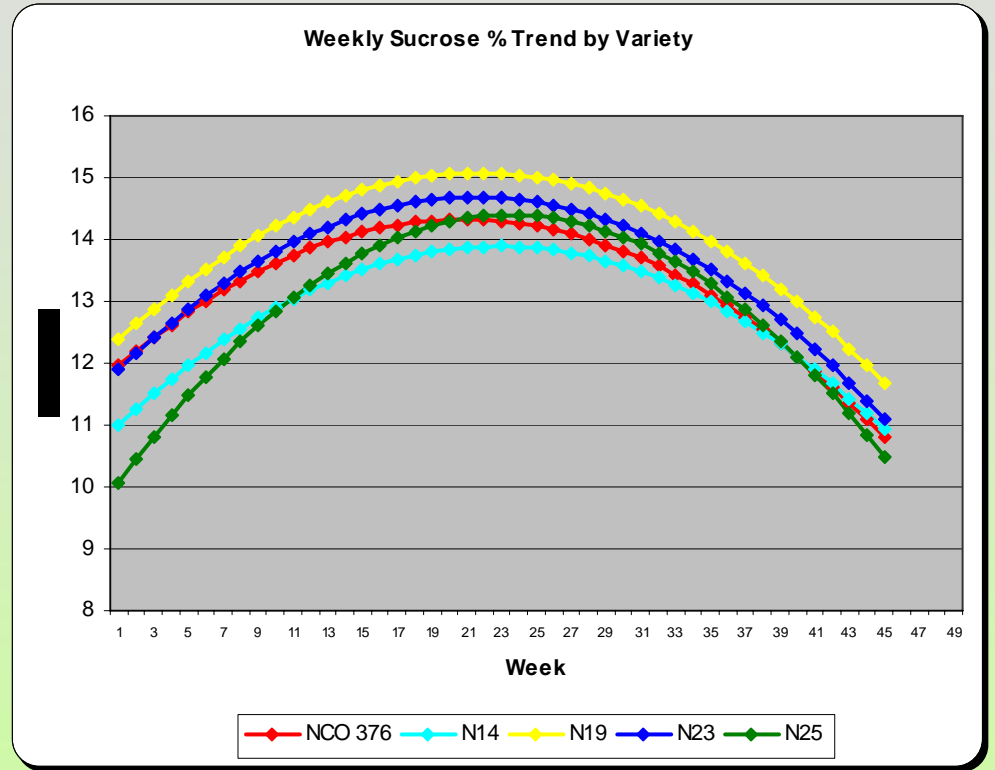
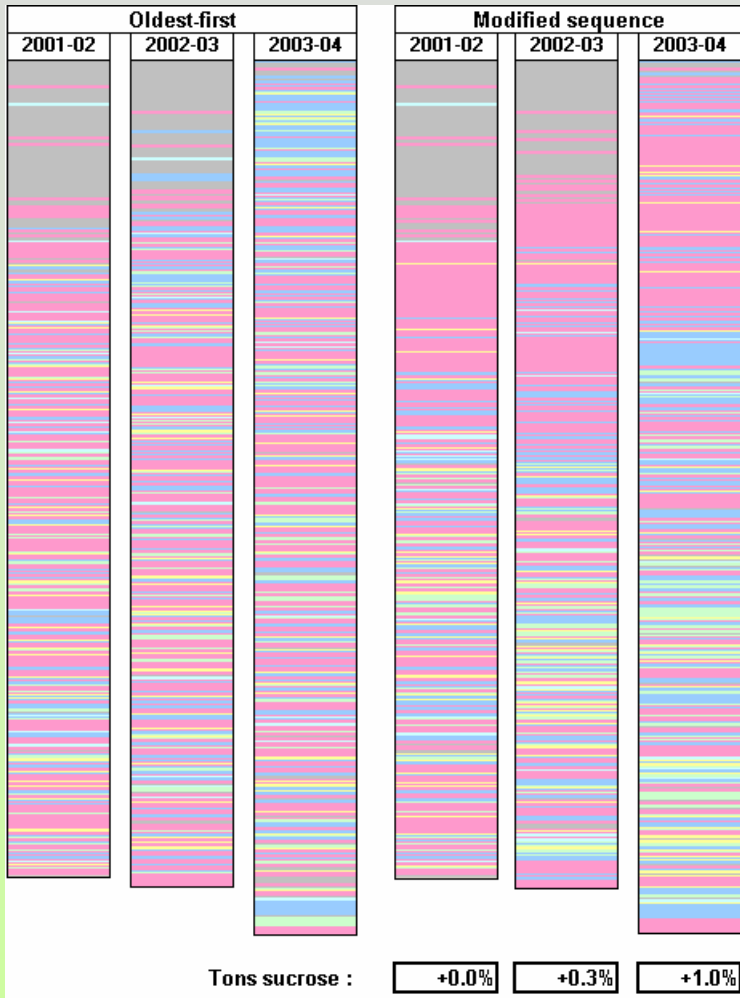
# Examples of model use in commercial operations – CanePro Cane Management Software

## 3. Harvest Sequencing

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# Harvest Planner Developments

- Optimise harvest sequence using knowledge of sugarcane physiology
    - Seasonal growth characteristics
    - Seasonal cane moisture profile
    - Seasonal cane sucrose curve
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**Quickly realised that to optimise harvest sequence one cannot ignore replanting and the need to accommodate the movement of fields to be replanted**

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# Examples of model use in commercial operations – CanePro Cane Management Software

## 4. Replant Planning

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# Replant Planning Concepts

- Identify fields to be replanted and when over a selected number of cutting seasons.
  - Identify which varieties should be used to replant each field to obtain an ideal variety mix.
  - Integrate a knowledge of replant dates into the harvest plan to optimise field sequencing over the chosen cutting seasons.
-

# Replant Planner Algorithm

## Setup

### Mill Specific Planting Seasons

- Duration
- Mill Crush Rate

### Planting Periods

- Duration
- Planting Capacity

### Yield Adjustment Factors

- Soil/Ratoon Matrix
- Irrigation Factors
- Variety Factors

### Sucrose Curves

- Variety, soil and mill specific

## Select Fields to Replant

1. Establish Field performance ranking using attainable yield concept over last 5 ratoons
2. Allow User to Modify Ranking
3. Estimate ideal replant ratoon for each field using:
  - 5 year mean field performance ratio
  - Subsequent soil/ratoon matrix
  - Planting capacity
4. Assign planting season based on ratio of current to ideal replant ratoon
5. Assign planting period based on relative advantage of moving forward or back in the replant period

## Ideal Variety Mix

1. Identify highest yielding variety for each day of season [tons sucrose]
2. Establish ideal estate variety composition
3. Establish adjusted ideal estate variety composition of each replant period based on:
  - Current variety composition
  - Variety exception constraints
  - Variety area constraints

## Final Output

1. Replant Plan
  - Plant Date
  - Variety
1. Adjusted Harvest Plan

# Step 1- Setup - Seasons

Replant Setup								
Seasons								
Cutting Season			DRD Source		DRD % Increase			
Name	Start date	End date	Use season	Days shift	CARGO CHOPPER	CARGO WHOLESTICK	UBOMBO CANE TRANSPORT	
2008-09	1/04/2008	31/12/2008	2007-08	0	-15.0	5.0	10.0	
Planting period								
Autumn 2007-08	1/02/2008	25/03/2008	31.0	239.1	9			
Spring 2008-09	1/07/2008	15/09/2008	80.0	880.0	6			
2009-10	1/04/2009	31/12/2009	2007-08	0	-15.0	5.0	20.0	
Planting period								
Autumn 2008-09	1/02/2009	25/03/2009	31.0	234.7	9			
Spring 2009-10	1/07/2009	15/09/2009	80.0	880.0	6			
2010-11	1/04/2010	31/12/2010	2007-08	0	-15.0	5.0	20.0	
Planting period								
Autumn 2009-10	1/02/2010	25/03/2010	31.0	234.7	9			
Spring 2010-11	1/07/2010	15/09/2010	80.0	880.0	6			
2011-12	1/04/2011	31/12/2011	2007-08	0	-15.0	5.0	20.0	
Planting period								
Autumn 2010-11	1/02/2011	25/03/2011	31.0	234.7	9			
Spring 2011-12	1/07/2011	15/09/2011	80.0	880.0	6			
2012-13	1/04/2012	31/12/2012	2007-08	0	-15.0	5.0	20.0	
Planting period								
Autumn 2011-12	1/02/2012	24/03/2012	31.0	234.7	9			
Spring 2012-13	1/07/2012	15/09/2012	80.0	880.0	6			
2013-14	1/04/2013	31/12/2013	2007-08	0	-15.0	5.0	20.0	
Planting period								
Autumn 2012-13	1/02/2013	25/03/2013	31.0	234.7	9			
Spring 2013-14	1/07/2013	15/09/2013	80.0	880.0	6			
2014-15	1/04/2014	31/12/2014	2007-08	0	-15.0	5.0	20.0	
Planting period								
Autumn 2013-14	1/02/2014	25/03/2014	31.0	234.7	9			
Spring 2014-15	1/07/2014	15/09/2014	80.0	880.0	6			
2015-16	1/04/2015	31/12/2015	2007-08	0	-15.0	5.0	20.0	
Planting period								
Autumn 2014-15	1/02/2015	25/03/2015	31.0	234.7	9			
Spring 2015-16	1/07/2015	15/09/2015	80.0	880.0	6			
2016-17	1/04/2016	31/12/2016	2007-08	0	-15.0	5.0	20.0	
Planting period								
Autumn 2015-16	1/02/2016	24/03/2016	31.0	234.7	9			
Spring 2016-17	1/07/2016	15/09/2016	80.0	880.0	6			

+ Add    X Delete

# Step 1- Setup – Soil/Ratoon matrix

Replant Setup

Excel Preview

Seasons Potential Yields Sucrose Curves

Soil Ratoon Matrix																	
Soil Category	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
B Set	0.921	0.901	0.882	0.862	0.842	0.822	0.802	0.783	0.763	0.743	0.723	0.703	0.684	0.664	0.644	0.624	0.604
C Set	0.982	0.975	0.969	0.962	0.955	0.949	0.942	0.935	0.928	0.922	0.915	0.908	0.902	0.895	0.888	0.882	0.875
D Set	0.938	0.927	0.916	0.905	0.894	0.883	0.872	0.861	0.851	0.840	0.829	0.818	0.807	0.796	0.785	0.774	0.763
F Set	0.938	0.927	0.916	0.905	0.894	0.883	0.872	0.861	0.851	0.840	0.829	0.818	0.807	0.796	0.785	0.774	0.763
I Set	0.792	0.777	0.762	0.747	0.732	0.717	0.702	0.687	0.672	0.657	0.642	0.627	0.612	0.597	0.582	0.567	0.552
K Set	0.983	0.968	0.952	0.937	0.922	0.907	0.892	0.877	0.862	0.842	0.832	0.817	0.801	0.786	0.771	0.756	0.741
L Set	0.947	0.938	0.929	0.920	0.911	0.902	0.893	0.884	0.875	0.866	0.857	0.848	0.839	0.830	0.821	0.812	0.803
N Set	0.947	0.938	0.929	0.920	0.911	0.902	0.893	0.884	0.875	0.866	0.857	0.848	0.839	0.830	0.821	0.812	0.803
R Set	1.000	0.992	0.985	0.977	0.970	0.962	0.954	0.947	0.939	0.932	0.924	0.917	0.909	0.901	0.894	0.886	0.879
S Set	0.948	0.943	0.938	0.933	0.928	0.923	0.918	0.913	0.908	0.903	0.898	0.893	0.888	0.883	0.878	0.873	0.868
T Set	0.972	0.963	0.955	0.946	0.938	0.929	0.921	0.912	0.904	0.895	0.887	0.878	0.870	0.861	0.853	0.844	0.836
U Set	0.792	0.777	0.762	0.747	0.732	0.717	0.702	0.687	0.672	0.657	0.642	0.627	0.612	0.597	0.582	0.567	0.552
V Set	0.907	0.882	0.857	0.832	0.807	0.782	0.757	0.732	0.706	0.681	0.656	0.631	0.606	0.581	0.556	0.531	0.506
W Set	0.921	0.901	0.882	0.862	0.842	0.822	0.802	0.783	0.763	0.743	0.723	0.703	0.684	0.664	0.644	0.624	0.604
Y Set	0.792	0.777	0.762	0.747	0.732	0.717	0.702	0.687	0.672	0.657	0.642	0.627	0.612	0.597	0.582	0.567	0.552

**Additional Factors**

**Irrigation System**

Center Pivot	1.000
Flood	1.000
Floppy	0.890
Furrow 1-5	0.920
Furrow 11-15	0.840
Furrow 6-10	0.860
Overhead	1.000
Portable Pipe Spl	1.000
Semi Solid-Set Spl	1.000
Sprinkler 1-5	0.890
Sprinkler 11-15	0.840
Sprinkler 6-10	0.870
Step-Down furrows	1.000
other furrows	0.000

**Variety**

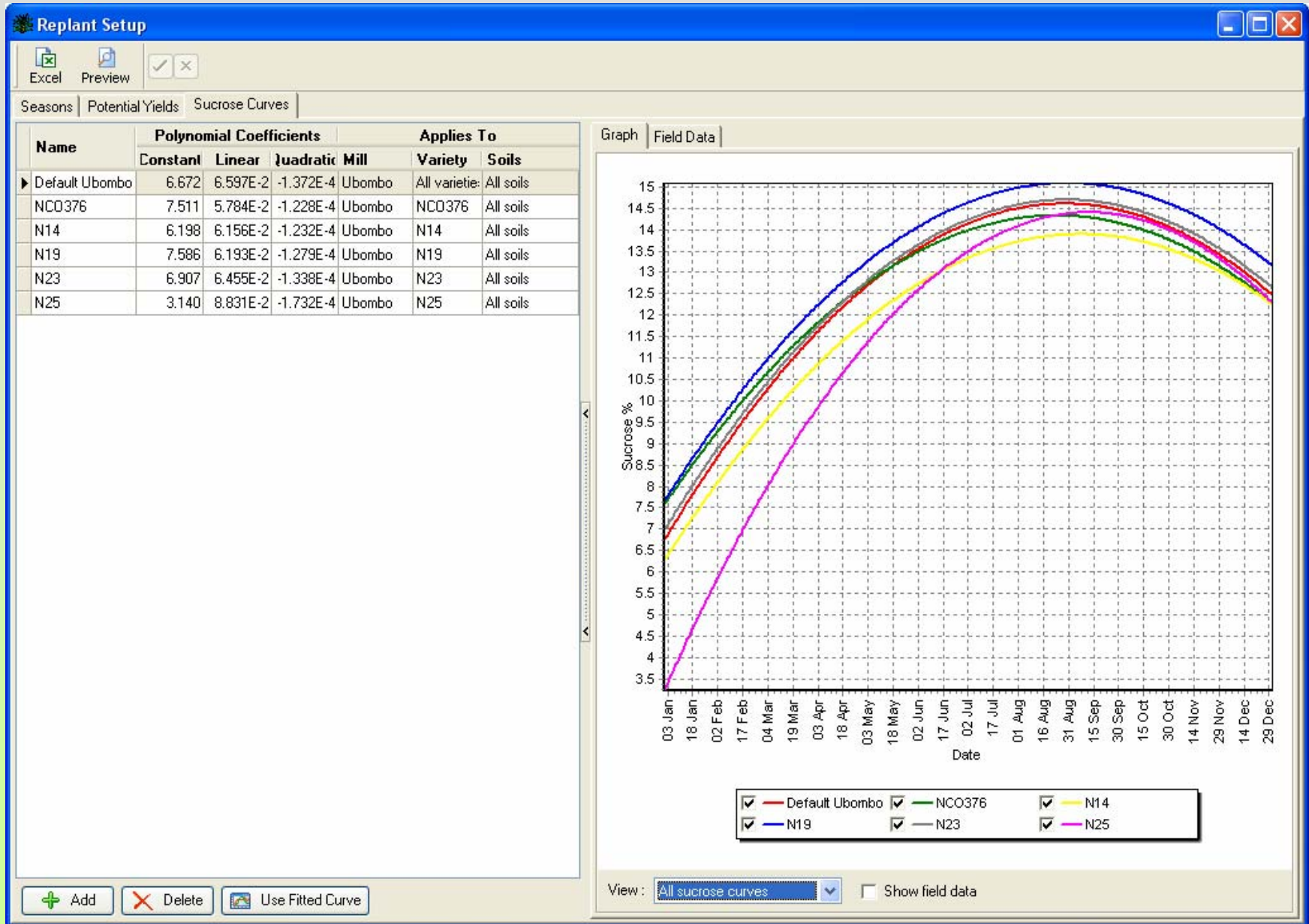
CP66	1.000
MIX	1.000
N14	0.960
N15	1.000
N17	1.000
N19	0.950
N22	0.830
N23	1.050
N24	0.850

**Factors In Use**

Factor	Active
Irrigation System	<input checked="" type="checkbox"/>
Variety	<input checked="" type="checkbox"/>

Copy Paste

# Step 1- Setup – Variety Quality Curves



# Step 2- Field Performance

**Replant Planner**

Excel Preview Filtering Grouping Field selection strategy : Declining yields Recalculate View Events  Optimise plant sequence  Optimise harvest sequence

Field Performance Variety Exclusions Area Constraints Replant Plan Long-Term Harvest Plan Scenarios Seed Requirements

+ Add Selected Field(s) to Replant Plan

Field Details						
Field	Area (ha)	Curr Variety	Curr Ratoon	Max Ratoon	Ratoon Ratio	Per
PPA03	12.5	N19	1	8.57	0.117	
PPA04	20.0	NCO376	6	8.71	0.689	
PPA05	17.0	N23	2	8.69	0.230	
PPA06	15.3	N23	3	10.19	0.295	
PPA07	14.1	N23	4	8.21	0.487	
PPA08	4.9	N23	7	7.89	0.887	
PPA09	13.5	N23	12	8.61	1.394	
PPA10	18.7	N23	2	9.29	0.215	
PPA11	5.6	N19	2	9.54	0.210	
PSPA1	24.0	N23	1	8.68	0.115	
PSPA2	27.0	N23	0	8.92	0.000	
PSPB	42.4	N23	8	8.35	0.958	
PSPC1	17.5	N23	11	8.34	1.319	
PSPC2	19.0	N19	1	8.51	0.117	
PSPC3	8.8	MIX	1	9.26	0.108	
PSPD	47.0	N23	1	7.98	0.125	
QBLA	17.7	N23	10	5.95	1.681	
QBLB	18.8	NCO376	9	6.88	1.307	
QBLC	32.6	N25	3	6.23	0.482	
QBLD1	26.4	N25	1	5.90	0.169	
QBLD2	15.7	N23	0	5.24	0.000	
QBLE1	19.5	N25	5	5.64	0.886	
QBLE2	16.0	N23	2	5.64	0.354	
<b>QBLF</b>	<b>14.2</b>	<b>N23</b>	<b>1</b>	<b>5.29</b>	<b>0.189</b>	
QBLG	9.8	N23	1	4.76	0.210	
QBLH	26.5	N23	0	6.03	0.000	
QB LI	15.5	N25	2	6.53	0.306	
QB LI	14.4	N25	4	5.30	0.755	

9897.7

Field does not have a valid quota

Field History						Cane Yield	
Season	Grow Start	Cut Date	Ratoon	Variety	Fit	Actual	Potential
2007-08	18/10/2006	12/10/2007	1	N23	<input checked="" type="checkbox"/>	123.45	118
2006-07	15/08/2005	17/10/2006	0	N23	<input checked="" type="checkbox"/>	126.79	136
2005-06	15/06/2004	18/05/2005	15	NCO376	<input checked="" type="checkbox"/>	77.56	137
2004-05	18/06/2003	14/06/2004	14	NCO376	<input checked="" type="checkbox"/>	90.51	150
2003-04	29/06/2002	17/06/2003	13	NCO376	<input checked="" type="checkbox"/>	107.13	145
2002-03	22/06/2001	28/06/2002	12	NCO376	<input checked="" type="checkbox"/>	113.45	141
2001-02	5/05/2000	24/06/2001	11	NCO376	<input checked="" type="checkbox"/>	85.24	151

**QBLF**

Actual/Corrected Potential

Ratoon

Legend:  
 Current cycle  
 Previous cycles  
 Excluded from fit  
 Soil/Ratoon  
 Fitted

Label points

Corrected potential yield = potential yield corrected for non-soil yield modifying factors

Ready

# Step 2- Variety Constraints

**Replant Planner**

Excel Preview Filtering Grouping Field selection strategy : Declining yields Recalculate View Events  Optimise plant sequence  Optimise harvest sequence

Field Performance Variety Exclusions Area Constraints Replant Plan Long-Term Harvest Plan Scenarios Seed Requirements

By Plant Variety By Location

Name	Variety		Autumn 2007-08 (ha)			Spring 2008-09 (ha)			Autumn 2008-09 (ha)			Spring 2009-10 (ha)		
	Current Area (%)	Planned (%)	Min	Max	Planned	Min	Max	Planned	Min	Max	Planned	Min	Max	Planned
CP66														
MIX	3.1													
N14	0.4													
N15														
N17														
N19	8.3	6.7	30.0	120.0		250.0	1200.0	89.9	250.0	1200.0	40.1	250.0	1200.0	
N22														
N23	36.1	24.7	60.0	260.0		250.0	1200.0	116.4	250.0	1200.0	59.9	250.0	1200.0	2
N24														
N25	22.4	38.7		0.0		250.0	1200.0	386.5		0.0		250.0	1200.0	4
N26														
N28														
N30														
N32														
N36		11.6				50.0	100.0	54.1				50.0	150.0	
N52/219														
N52\219														
NC0376	29.7	18.4	40.0	120.0		250.0	1200.0	236.4	250.0	1200.0	147.3	250.0	1200.0	
<b>TOTAL</b>	100.0	100.0	130.0		0.0	1050.0		883.3	750.0		247.3	1050.0		8
<b>CAPACITY</b>					239.1			880.0			234.7			8

Ready

# Step 3- Replant Plan

**Replant Planner**

Excel Preview Filtering Grouping Field selection strategy : Declining yields Recalculate View Events  Optimise plant sequence  Optimise harvest sequence

Field Performance Variety Exclusions Area Constraints Replant Plan Long-Term Harvest Plan Scenarios Seed Requirements

Field Details					Replant Details				
Field	Area (Ha)	Current Ratoon	Current Variety	Season	Plant Period	Period Locked	New Variety	Variety Locked	Plant Date
LMH03	9.2	9	NCO376	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	NCO376	<input checked="" type="checkbox"/>	1/07/2008
LMH04	5.5	4	N23	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	N25	<input checked="" type="checkbox"/>	1/07/2008
LMH07	7.2	7	N23	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	NCO376	<input checked="" type="checkbox"/>	2/07/2008
LMU09	6.7	13	NCO376	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	N25	<input checked="" type="checkbox"/>	2/07/2008
LMU10	6.8	7	N25	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	N25	<input checked="" type="checkbox"/>	25/07/2008
LTA02	31.0	11	NCO376	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	N25	<input checked="" type="checkbox"/>	3/07/2008
LTA03	21.0	11	NCO376	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	N25	<input checked="" type="checkbox"/>	6/07/2008
LTA10	12.4	6	N25	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	N25	<input checked="" type="checkbox"/>	28/07/2008
LWV04	16.7	8	N23	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	NCO376	<input checked="" type="checkbox"/>	8/07/2008
QCO02	23.5	7	MIX	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	NCO376	<input checked="" type="checkbox"/>	9/07/2008
TTJ02D	16.2	1	N25	2009-10	Autumn 2008-09	<input type="checkbox"/>	N19	<input type="checkbox"/>	1/02/2009
TTJ12	8.4	13	NCO376	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	NCO376	<input checked="" type="checkbox"/>	11/07/2008
TTJ22A	12.5	9	NCO376	2009-10	Autumn 2008-09	<input checked="" type="checkbox"/>	NCO376	<input checked="" type="checkbox"/>	4/02/2009
TTJ22B	12.5	9	NCO376	2009-10	Autumn 2008-09	<input checked="" type="checkbox"/>	NCO376	<input checked="" type="checkbox"/>	7/02/2009
TTJ22D	12.5	9	NCO376	2009-10	Autumn 2008-09	<input checked="" type="checkbox"/>	NCO376	<input checked="" type="checkbox"/>	10/02/2009
VML01	10.7	7	NCO376	2009-10	Autumn 2008-09	<input checked="" type="checkbox"/>	N19	<input checked="" type="checkbox"/>	13/02/2009
VNZ02	11.2	10	N25	2008-09	Spring 2008-09	<input type="checkbox"/>	N19	<input type="checkbox"/>	12/07/2008
VSH02	34.0	4	N25	2008-09	Spring 2008-09	<input checked="" type="checkbox"/>	N25	<input checked="" type="checkbox"/>	13/07/2008
LMH06	8.0	10	N19	2008-09	Spring 2008-09	<input type="checkbox"/>	N25	<input type="checkbox"/>	16/07/2008
LMU03	10.2	11	NCO376	2008-09	Spring 2008-09	<input type="checkbox"/>	N25	<input type="checkbox"/>	23/07/2008
568	8258.2								

Remove from Plan Select All Set Selected Update Plant Sequence Update Field History...

Ready

# Step 3- Long Term Harvest Plan

**Replant Planner**

Excel Preview Filtering Grouping Field selection strategy : Declining yields Recalculate View Events  Optimise plant sequence  Optimise harvest sequence

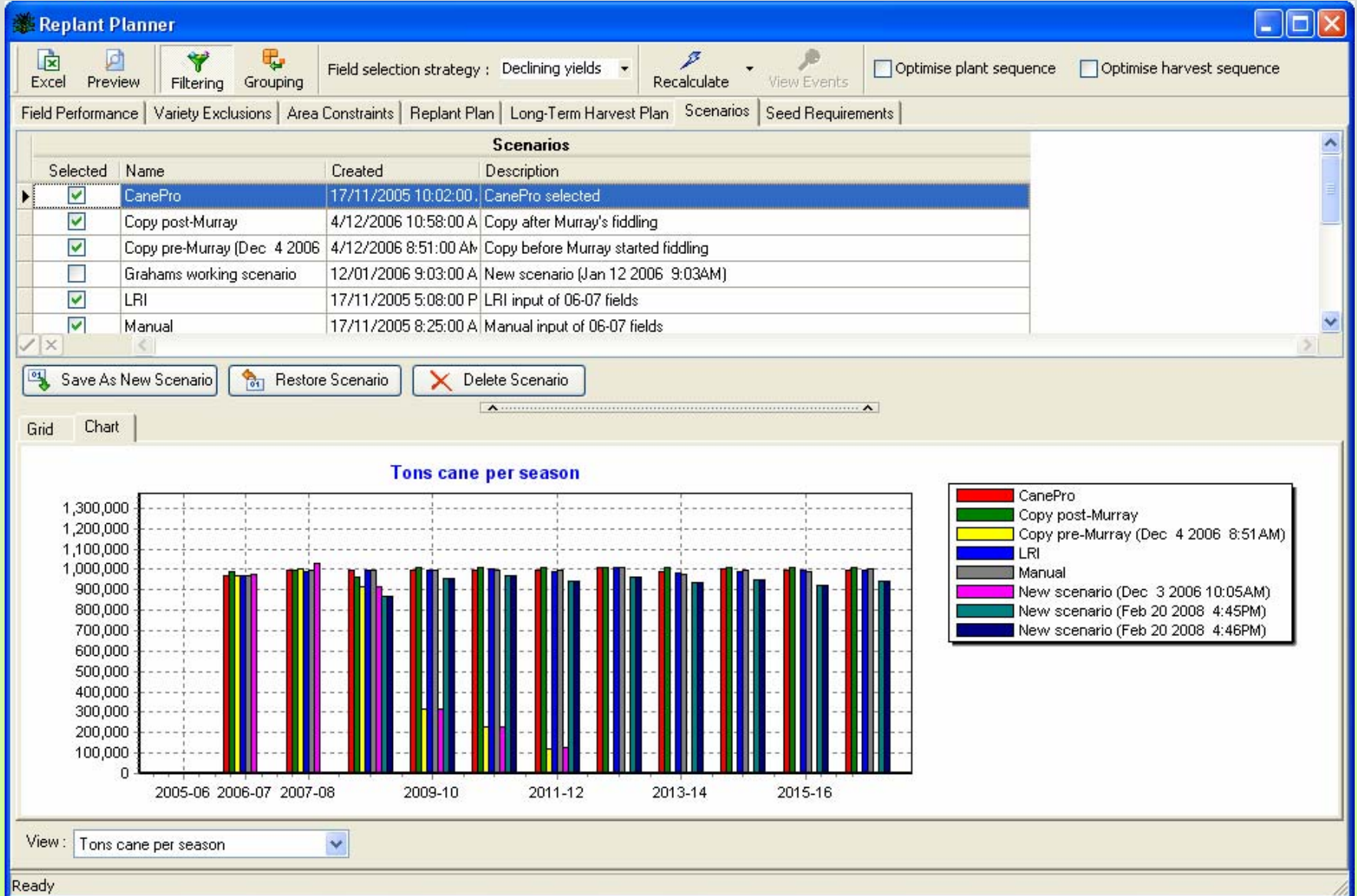
Field Performance Variety Exclusions Area Constraints Replant Plan Long-Term Harvest Plan Scenarios Seed Requirements

Harvestings Fields Carried Over Cut Front Utilisation % of Area Harvested By Variety % of Area Harvested By Ratoon Age Distribution Monthly Area Harvested By Variety

Field Details										Harvest Del
Field Name	Area (Ha)	Ratoon	Variety	Grow Start	Mill	Cutting Front	Cut Date	Cut Age	Season	Tons Ca
VGI02	15.5	6	N23	18/05/2007	Ubombo	CARGO WHOLESTICK	29/07/2008	14.39	2008-09	
SFIW	33.0	6	N23	10/09/2007	Ubombo	UBOMBO CANE TRAN:	29/07/2008	10.61	2008-09	
PMR14	3.3	3	NCO376	12/09/2007	Ubombo	UBOMBO CANE TRAN:	31/07/2008	10.61	2008-09	
HSO05	17.3	0	N25	12/09/2007	Ubombo	UBOMBO CANE TRAN:	31/07/2008	10.61	2008-09	
VGI03	14.1	9	NCO376	16/05/2007	Ubombo	CARGO WHOLESTICK	31/07/2008	14.52	2008-09	
PMR15	4.7	3	NCO376	12/09/2007	Ubombo	UBOMBO CANE TRAN:	31/07/2008	10.61	2008-09	
VGI07	10.0	5	NCO376	27/08/2007	Ubombo	CARGO WHOLESTICK	1/08/2008	11.17	2008-09	
PMR16	1.0	4	NCO376	12/09/2007	Ubombo	UBOMBO CANE TRAN:	1/08/2008	10.65	2008-09	
TTJ01D	13.2	13	NCO376	14/09/2007	Ubombo	CARGO CHOPPER	1/08/2008	10.58	2008-09	
PMR23C	18.0	3	NCO376	12/09/2007	Ubombo	UBOMBO CANE TRAN:	1/08/2008	10.65	2008-09	
PMR23A	12.5	4	N23	12/09/2007	Ubombo	UBOMBO CANE TRAN:	1/08/2008	10.65	2008-09	
SFLE	29.0	2	NCO376	13/09/2007	Ubombo	UBOMBO CANE TRAN:	2/08/2008	10.65	2008-09	
MSL04	44.8	4	N23	2/07/2007	Ubombo	CARGO CHOPPER	2/08/2008	13.05	2008-09	
VML04	11.6	2	NCO376	15/05/2007	Ubombo	CARGO WHOLESTICK	2/08/2008	14.62	2008-09	
HPA21	11.6	3	NCO376	15/09/2007	Ubombo	UBOMBO CANE TRAN:	3/08/2008	10.61	2008-09	
VDR01	36.5	18	NCO376	4/07/2007	Ubombo	CARGO WHOLESTICK	3/08/2008	13.01	2008-09	
SFU	29.7	5	N25	14/09/2007	Ubombo	UBOMBO CANE TRAN:	3/08/2008	10.65	2008-09	
HPA12	8.8	1	N23	15/09/2007	Ubombo	UBOMBO CANE TRAN:	4/08/2008	10.65	2008-09	
SHS02	23.0	2	N23	17/09/2007	Ubombo	UBOMBO CANE TRAN:	4/08/2008	10.58	2008-09	
4327	80437.3							12.10		

Ready

# Step 4- Scenarios



# Advantages

- Improves replant field selection decisions
  - Place varieties in the right time of the season to optimise overall season yield
  - Optimise long-term harvest plan to minimize age effects
  - Scenarios allow evaluation of decisions on overall sucrose yield
-

# Examples of model use in commercial operations – CanePro Cane Management Software

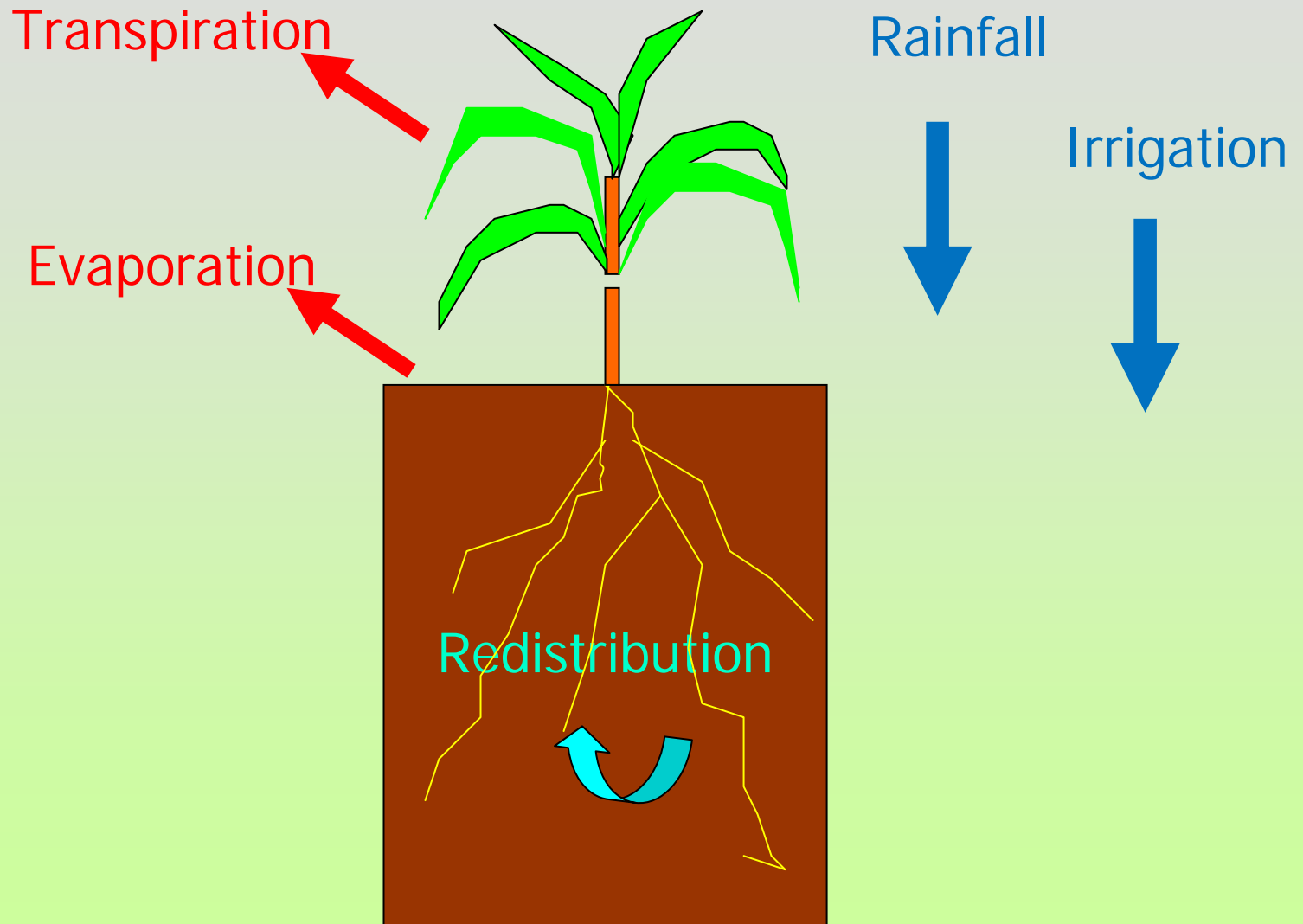
## 5. Irrigation Scheduling

---

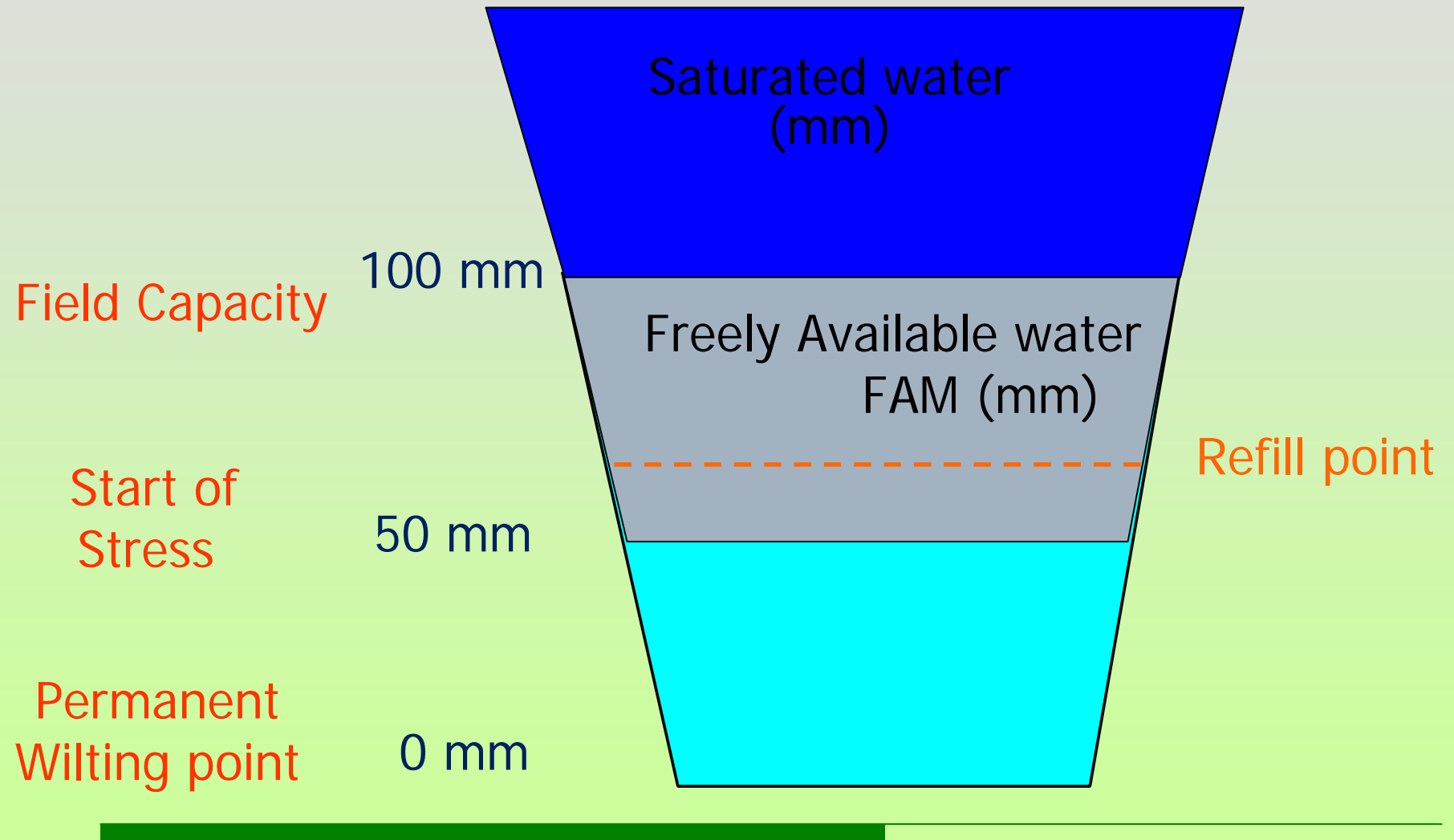
# Irrigation Scheduling Concept

- Water balance
  - Soil water concepts
  - Estimating components of the water balance
-

# Water Balance



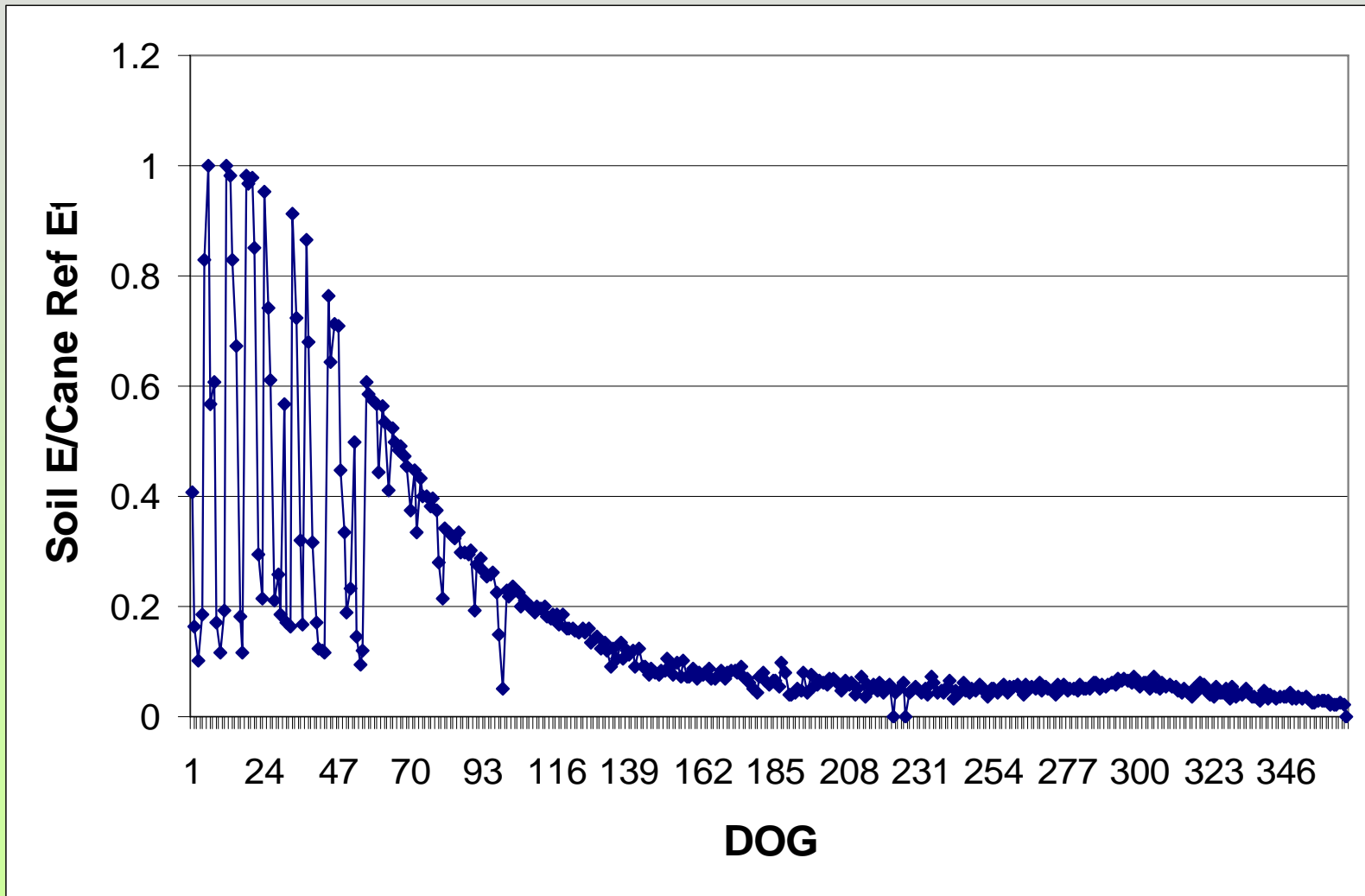
# Soil Water Concepts



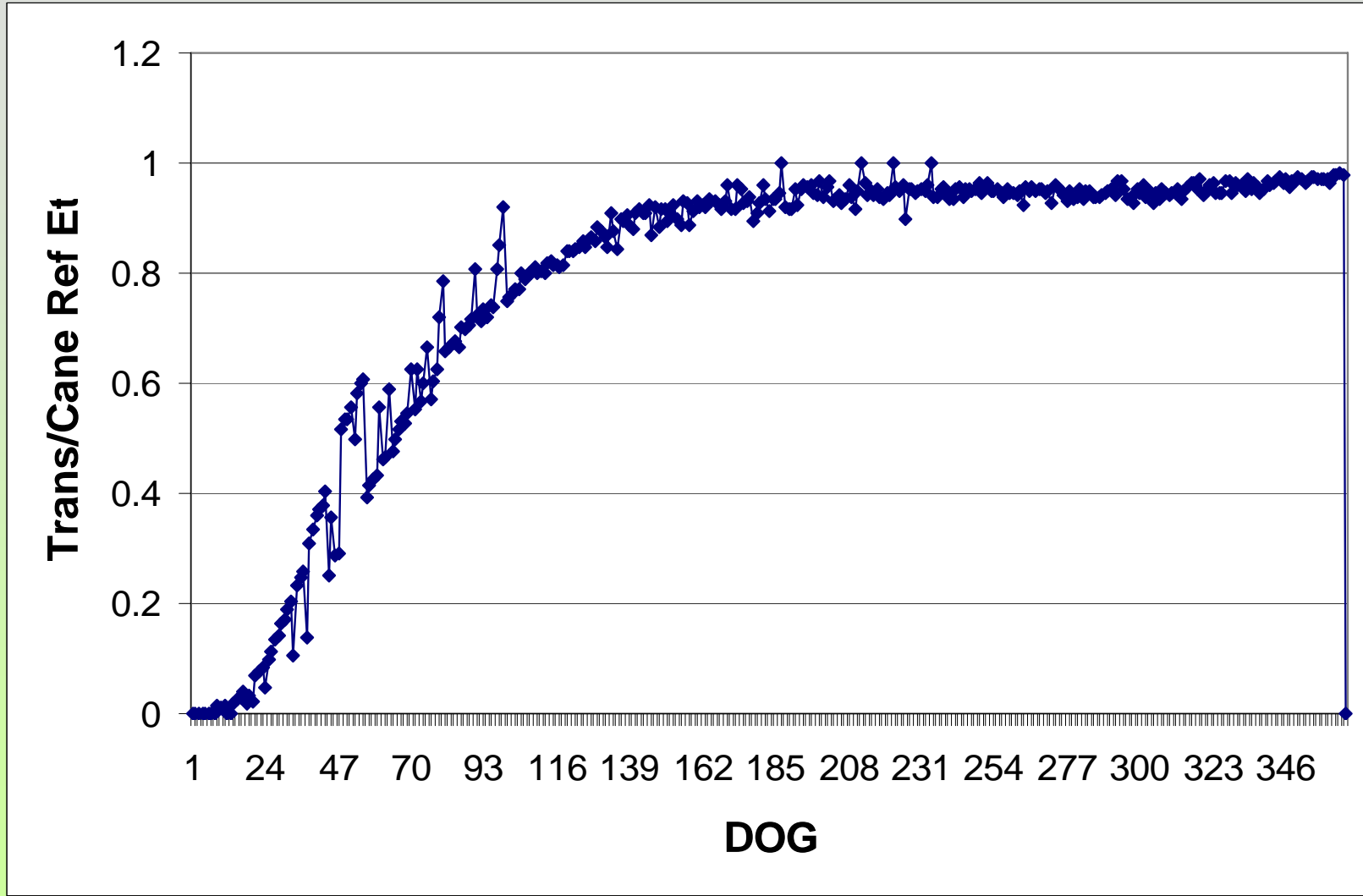
# Estimating components of the water balance

- Evaporation + transpiration – Potential Et calculated using Penman-Monteith
  - Soil evaporation calculated separately from transpiration
  - Rainfall and estimate of net irrigation as direct inputs
-

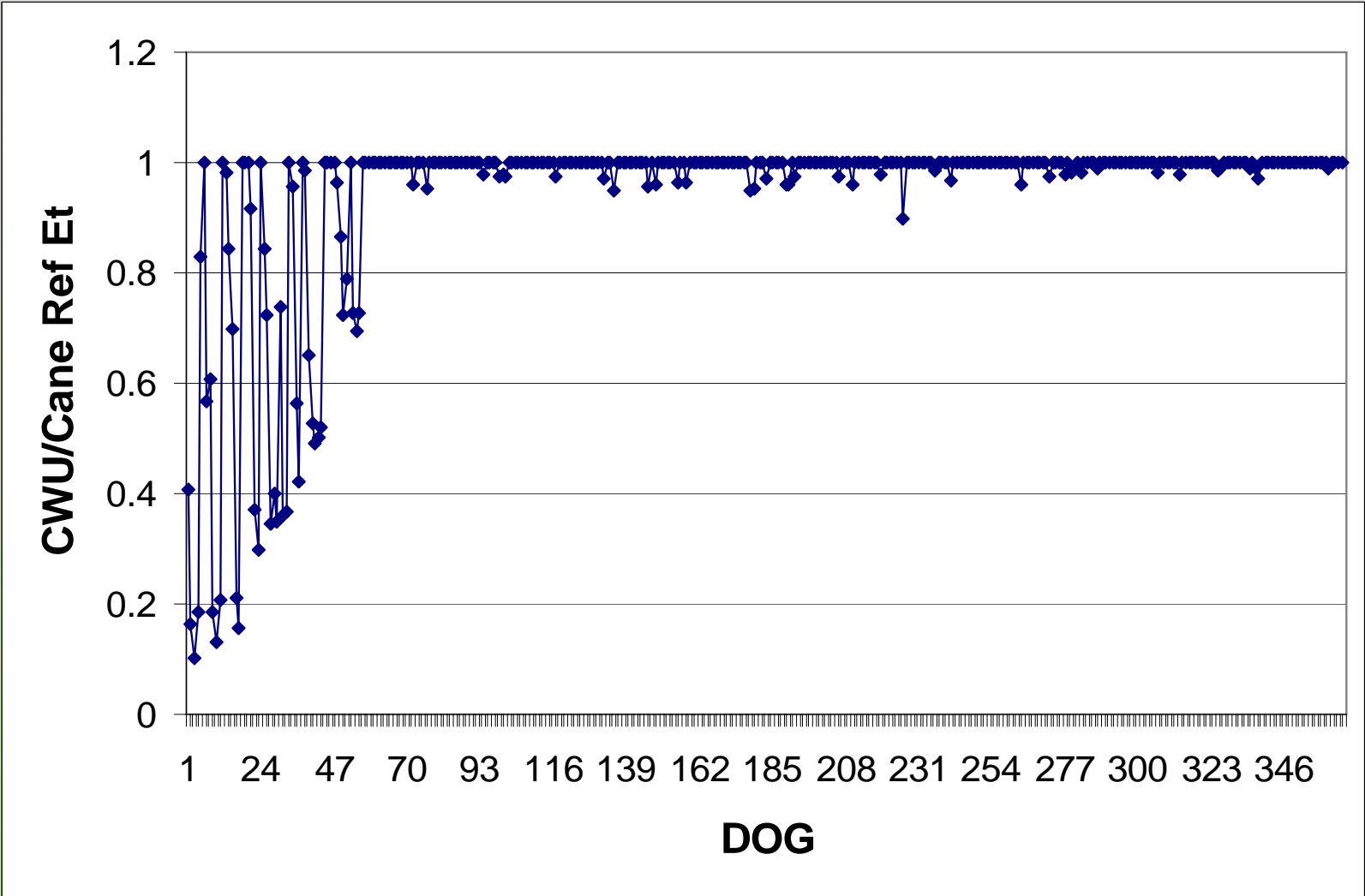
# Soil Evap. as a % of Pot Et



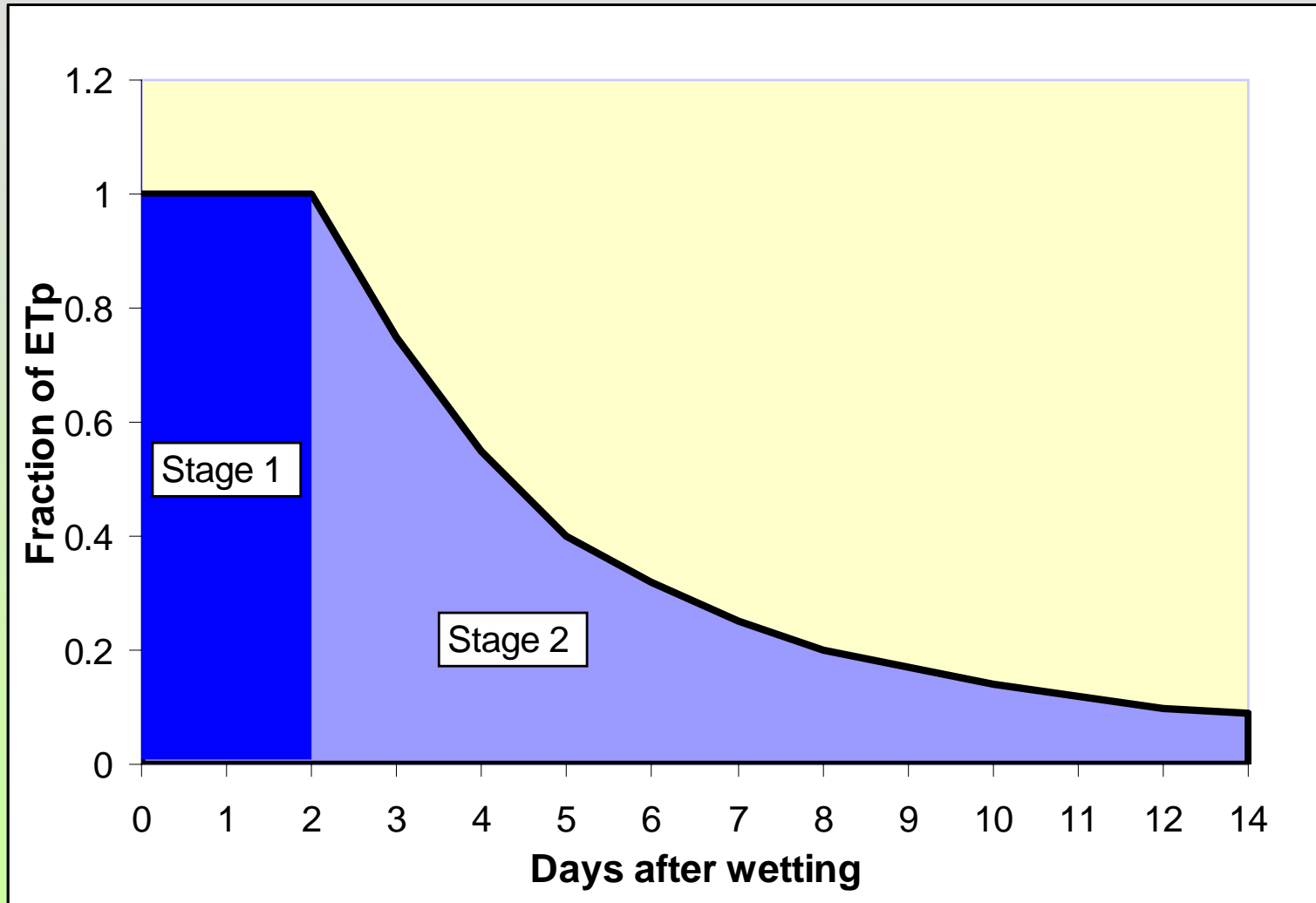
# Transpiration as a % of Pot Et



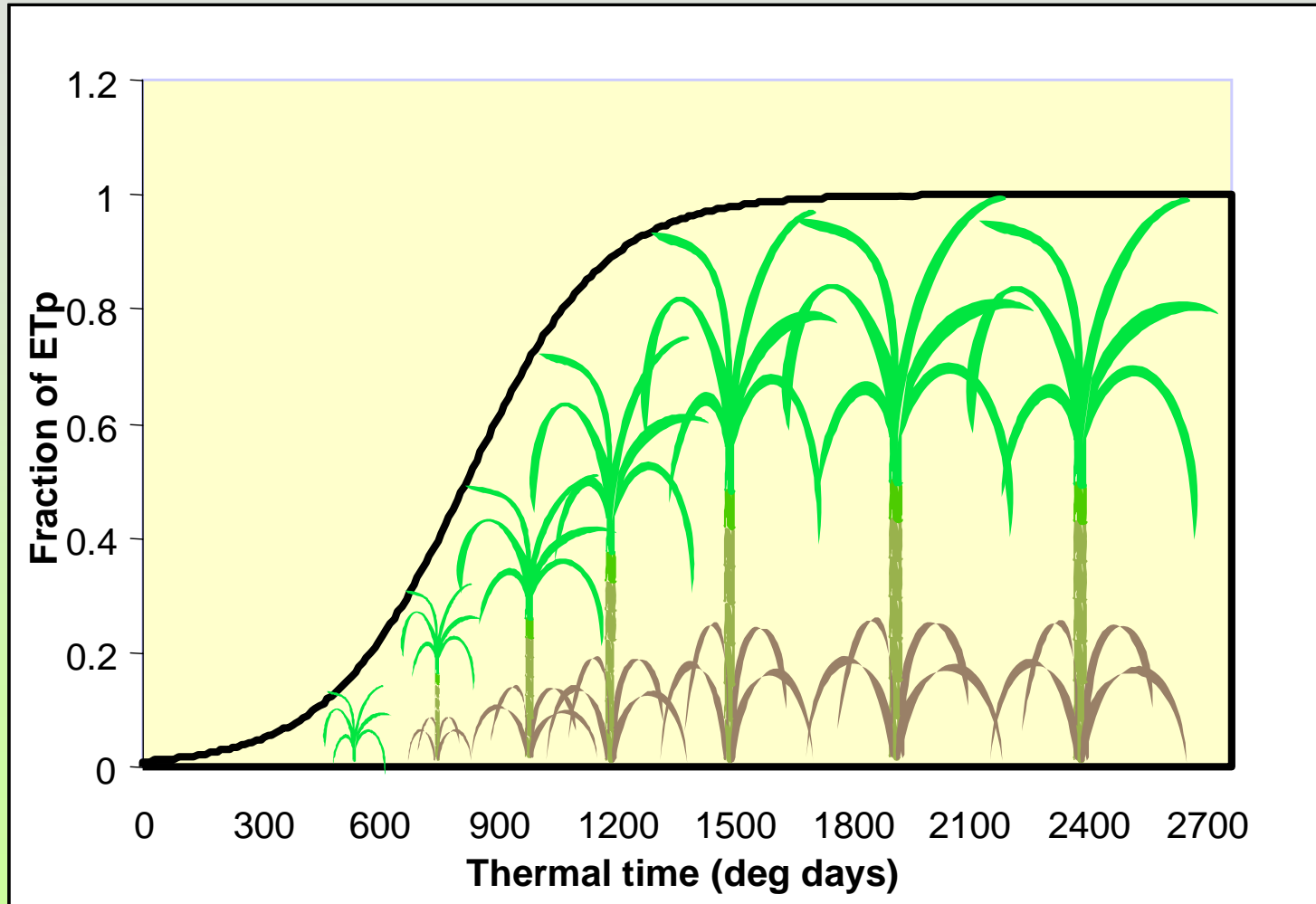
# CWU as a % of Pot Et



# Two-Stage Soil Evaporation Model



# Transpiration – Thermal Time-based Canopy Development Model



# Field soil details

**Irrigation Scheduling for Season Current under Location Section - 01**

Excel Preview Edit Graph  Show cum. Rainfall Drag Curve Edit Comments Hide Grids + - ✓ x

General Rainfall Irrigation Canopy development Daily WB Graph Graph data

Location

- 01
  - S00501
  - S00502
  - S00503
  - S00504
  - S00505
  - S00506
  - S00701
  - S00702
  - S00703
  - S00704
  - S00801
  - S00802
  - S00803
  - S00804
  - S00805
  - S00806
  - S00807
  - S00808

Field Details - General	
Field Name	S00501
Ratoon	1
Grow Start Date	30/08/2007
Harvest Date	6/08/2008
Met. Site	Mlaula AWS
Rain Gauge	ML01-Gauge 1
Irrigation System	Sprinkler (24 mm)

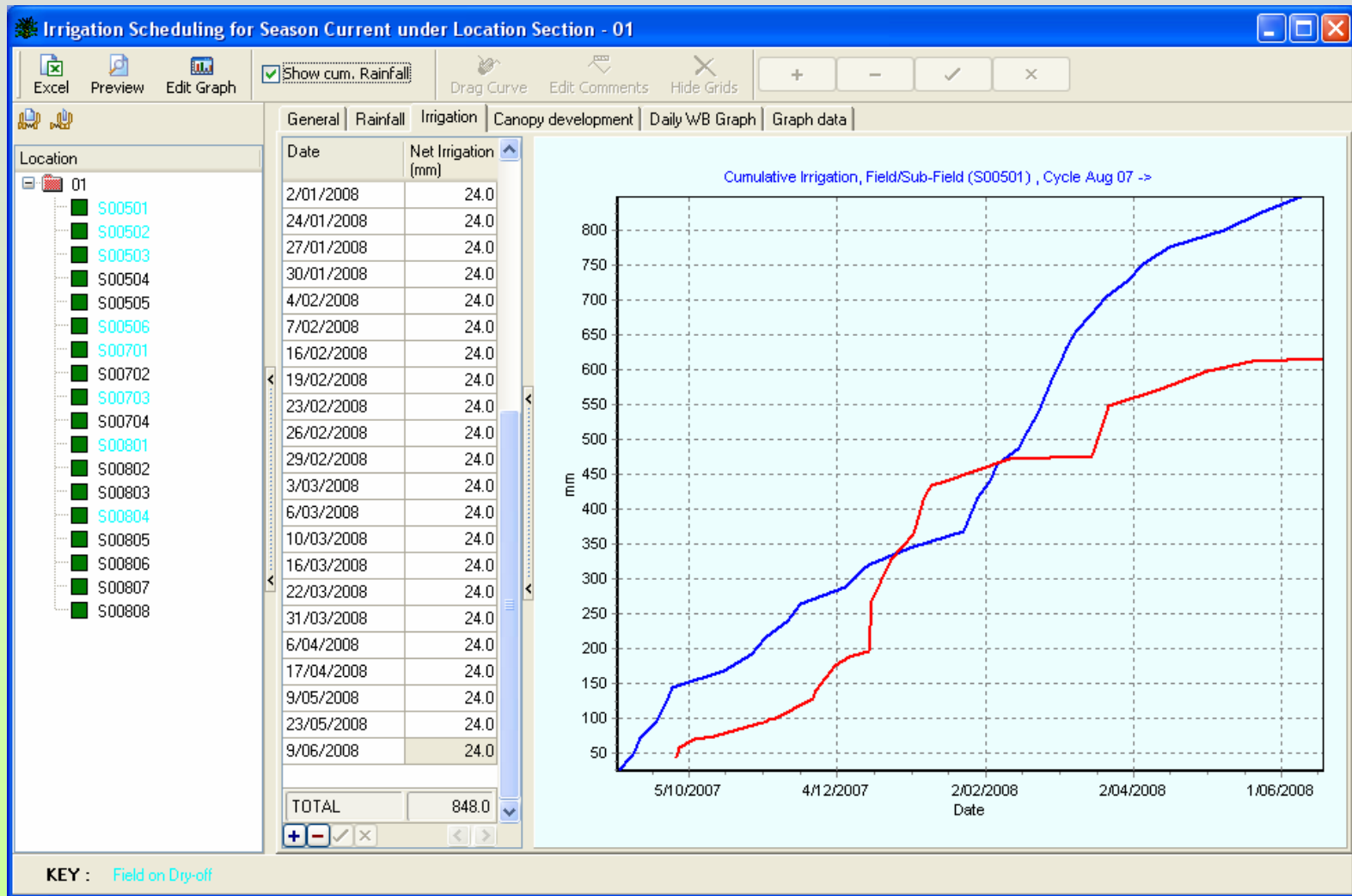
Irrigation System Details	
Irrigation System	Sprinkler (24 mm)
Wetted Area(%)	100
Typical Net App. (mm)	24
Minimum Cycle Time (days)	3
Typical App. Efficiency (%)	75

Soil Details	
TAM (mm)	70
FAM(mm)	35
Refill Point (mm)	35
Starting SWB (mm)	0
Drain Days	2

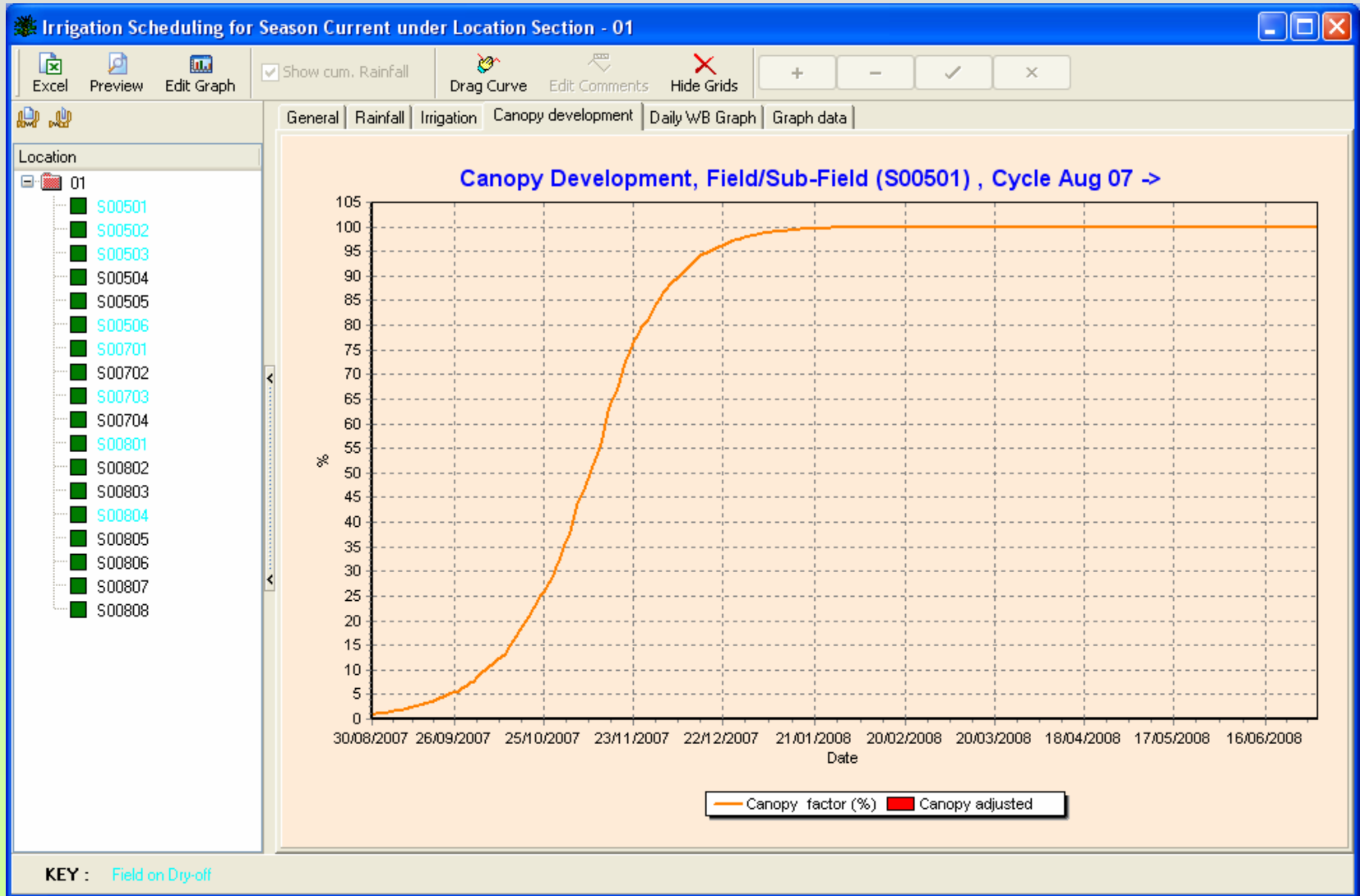
Dry-Off Details	
Dry-off Date	20/06/2008
Multiple of TAM	2.5
Dry-off TAM (mm)	70
Link Dry-off to Last Spray Date?	<input type="checkbox"/>

KEY : Field on Dry-off

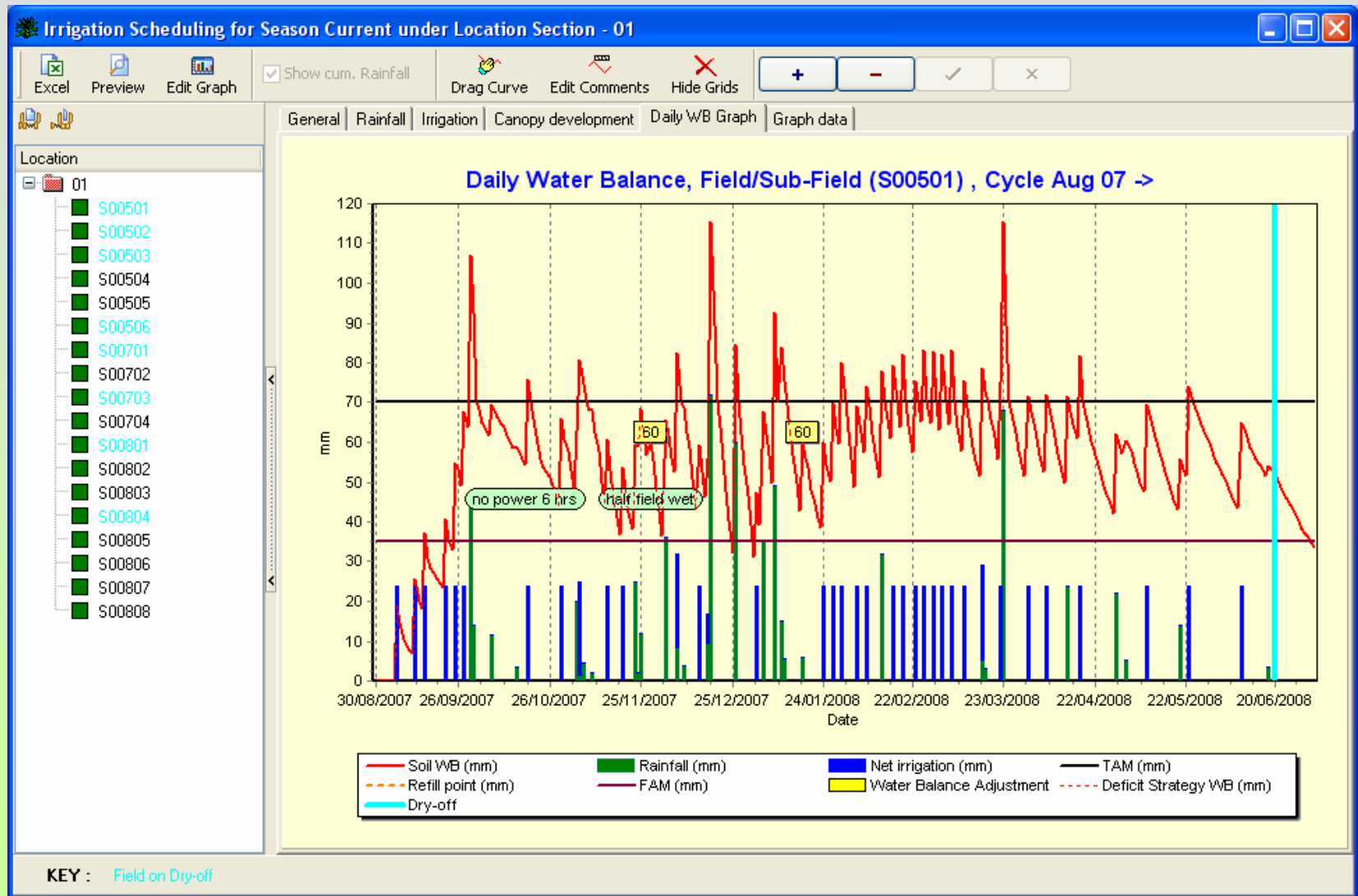
# Irrigation & Rainfall



# Canopy Development



# Water balance



# Weekly Schedule

Schedule Week at a Time Starting 3/07/2008 and Location

View Demand

Hierarchy	Current soil water details (2/07/2008)				Irrig. between		Net Irrigation Application (mm)							Gross Volume (ML)						
	locName	Current WB (m...)	TAM (mm)	FAM (mm)	Refill Point (mm)	2/07/2008 & 3/07/2008 (mm)	Thursday ...	Friday ...	Saturda...	Sunday...	Monda...	Tuesda...	Wedne...	Thursda...	Friday 4...	Saturda...	Sunday ...	Monday...	Tuesda...	Wednes...
01														10.08	10.08	10.08		2.40	8.84	8.84
S00501			70	35	35	0.0														
S00502			70	35	35	0.0														
S00503			65	33	33	0.0														
S00504		29.8	75	33	33	0.0	24.0						2.78	2.78	2.78					
S00505		33.7	85	43	43	0.0	24.0						3.02	3.02	3.02					
S00506			85	43	43	0.0														
S00701			75	38	38	0.0														
S00702		65.6	75	38	38	0.0														
S00703			75	38	38	0.0														
S00704		57.7	75	38	38	0.0														
S00801			75	38	38	0.0														
S00802		38.6	65	33	33	0.0				24.0								2.40	2.40	2.40
S00803		39.8	60	30	30	0.0														
S00804			85	43	43	0.0														
S00805		64.8	85	43	43	0.0														
S00806		40.3	65	33	33	0.0					24.0								6.44	6.44
S00807		39.8	60	30	30	0.0														
S00808		26.9	60	30	30	0.0	24.0						4.28	4.28	4.28					

KEY : Field on Dry-off Current WB < FAM

# Advantages

- Improve water use efficiency
  - Raise awareness of irrigation on the estate
  - Improve logistics of water-ordering
-

# Conclusions

- Models have the ability to provide physiologically based decision-support tools to commercial operations
  - Allows for wide adoption of new technology through client base
  - Improve yields through better decisions
  - Save costs through better monitoring and control
-